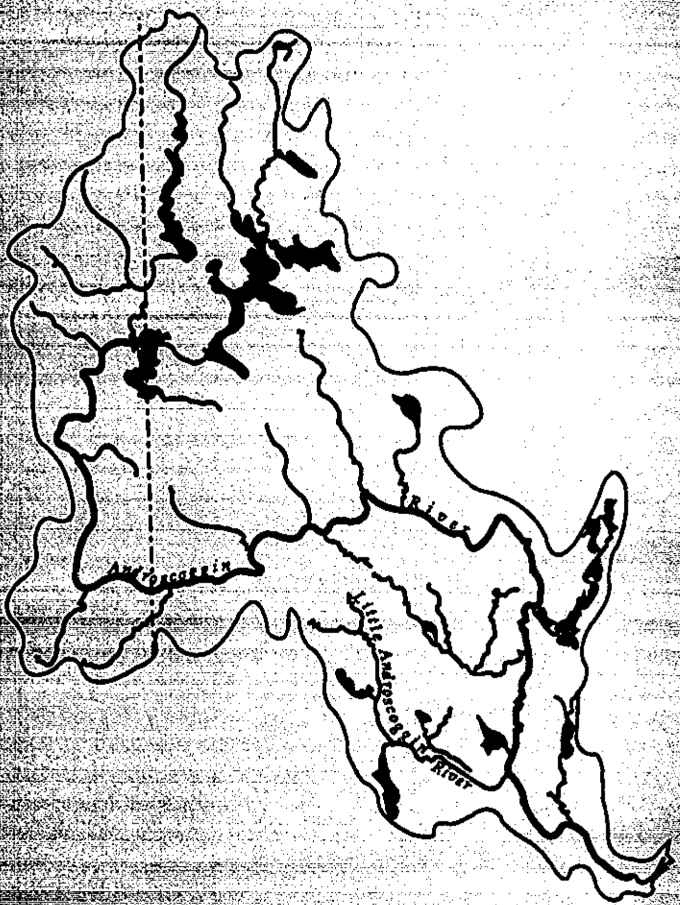
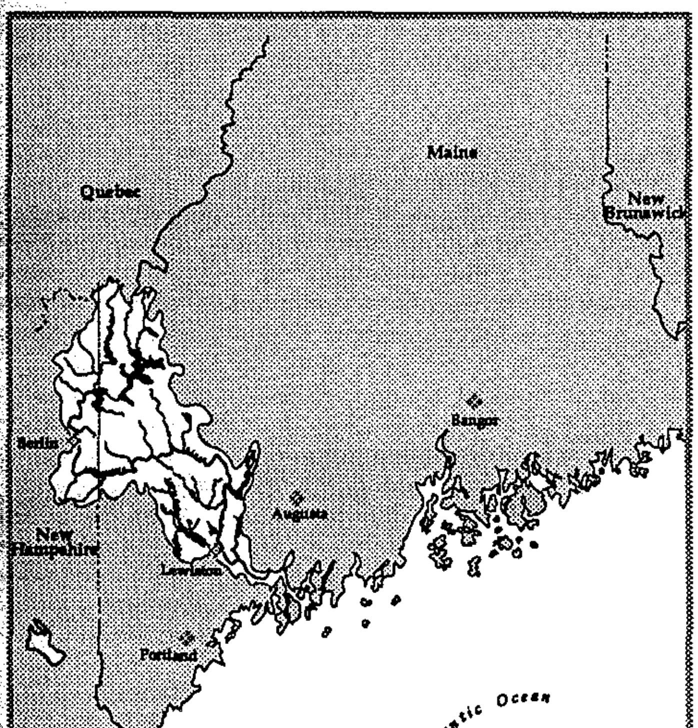
# Reconnaissance Report

## Androscoggin River Basin
## Maine

Volume II
(Appendices)

# Water Resources Study




Androscoggin River Basin Location

April 1989

US Army Corps
of Engineers
New England Division

ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

APRIL 1989

VOLUME II

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ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

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ANDROSCOGGIN RIVER BASIN
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APPENDIX A

CORRESPONDENCE

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NEW HAMPSHIRE
NATURAL HERITAGE
INVENTORY

Joseph L. Ignazio
Chief, Planning Division
Dept. of the Army
NE Div., Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

28 February 1989

RE: Environmental review of the Androscoggin River Basin in Coos County, New Hampshire.

Dear Mr. Ignazio:

Thank you for consulting the New Hampshire Natural Heritage Inventory regarding the presence of rare plants, animals and exemplary natural communities (hereafter referred to as `elements') located in the Androscoggin Watershed.

Enclosed is a list of the "elements" (rare plants, animals and natural communities) known from within the boundaries of the study area. The lists include both federal and state status as well as a state and global rank. An explanation of the ranking system used by the Heritage Inventory is included.

Please note that this information on environmental elements is not the result of comprehensive field surveys. For this reason, the New Hampshire Natural Heritage Inventory cannot provide a definitive statement on the presence, absence, or status of species or natural communities in the area under consideration. It should also be noted that more data on this area may become available in the future as the inventory expands with ongoing fieldwork and research.

For a more thorough evaluation, it is recommended that a field survey be conducted in the area under consideration.

Sincerely,

Edie E. Hentcy

Edie E. Hentcy
Data Manager/Biologist

Enclosure

cc: Ed Spencer - The Nature Conservancy - NH

Department of Resources and Economic Development
PO Box 856 CONCORD N.H. 03302-0856

603-271-3623

| SRank | GRank | Federal | State | Scientific Name | Common Name | TOWNNAME |
|---|---|---|---|---|---|---|
| S2Q | G5 | | | ACHILLEA BOREALIS | NORTHERN YARROW | MT. WASHINGTON |
| S3 | G? | | | AGROSTIS BOREALIS | BOREAL BENTGRASS | LOW AND BURBANKS GR |
| S3 | G5 | | | ARDEA HERODIAS | GREAT BLUE HERON (ROOKERY) | ERROL |
| S1 | G2G4 | | | ARNICA LANCEOLATA | ARNICA | SHELBURNE |
| SH | G? | | SE | ASTER CRENIFOLIUS VAR. ARCUANS | LEAFY-BRACTED ASTER | BERLIN |
| S2 | G5 | | | AYTHYA COLLARIS | RING-NECKED DUCK | ERROL |
| S2 | G5 | | | AYTHYA COLLARIS | RING-NECKED DUCK | ERROL |
| S2 | G5 | | | AYTHYA COLLARIS | RING-NECKED DUCK | ERROL |
| S2 | G5 | | | AYTHYA COLLARIS | RING-NECKED DUCK | ERROL |
| S2 | G5 | | | AYTHYA COLLARIS | RING-NECKED DUCK | WENTWORTH'S LOCATIC |
| S1 | G4G5 | | ST | BETULA GLANDULOSA | DWARF BIRCH | THOMPSON AND MESERV |
| S2 | G4G5 | | | BETULA MINOR | SMALL BIRCH | RANDOLPH |
| S2 | G4G5 | | | BETULA MINOR | SMALL BIRCH | THOMPSON AND MESERV |
| S3 | G5T? | | | CALAMAGROSTIS CANADENSIS VAR ROBUSTA | BLUE-JOINT REEDGRASS | BEAN'S PURCHASE |
| S3 | G3 | | ST | CALAMAGROSTIS PICKERINGII | PICKERING'S REED BENT-GRASS | SARGENT'S PURCHASE |
| SU | G? | | SE | CALAMAGROSTIS STRICTA VAR INEXPANSA | NEGLECTED REED BENT-GRASS | MT. WASHINGTON |
| SH | G5 | | | CALLITRICHE ANCEPS | NORTHERN WATER-STARWORT | RANDOLPH |
| S1 | G5 | | | CAMPANULA ULIGINOSA | GREATER MARSH-BELLFLOWER | SHELBURNE |
| S1 | G5 | | SE | CAMPTOSORUS RHIZOPHYLLUS | WALKING-FERN SPLEENWORT | SHELBURNE |
| S1 | G5 | | SE | CARDAMINE BELLIDIFOLIA | ALPINE BITTER-CRESS | GREEN'S GRANT |
| S1 | G5 | | SE | CARDAMINE BELLIDIFOLIA | ALPINE BITTER-CRESS | MT. WASHINGTON |
| S1 | G5 | | SE | CARDAMINE BELLIDIFOLIA | ALPINE BITTER-CRESS | THOMPSON AND MESERV |
| S1 | G5 | | SE | CARDAMINE BELLIDIFOLIA | ALPINE BITTER-CRESS | GREEN'S GRANT |
| S2 | G5 | | SE | CAREX ABDITA | HIDDEN SEDGE | RANDOLPH |
| S2 | G5 | | SE | CAREX ABDITA | HIDDEN SEDGE | MT. WASHINGTON |
| S3 | G5 | | | CAREX BIGELOWII | BIGELOW'S SEDGE | MT. WASHINGTON |
| S3 | G5 | | | CAREX BIGELOWII | BIGELOW'S SEDGE | MT. WASHINGTON |
| S3 | G5 | | | CAREX BIGELOWII | BIGELOW'S SEDGE | MT. WASHINGTON |
| S1 | G5T5 | | ST | CAREX CAPILLARIS VAR CAPILLARIS | HAIR-LIKE SEDGE | THOMPSON & MESERVES |
| S1 | G? | | ST | CAREX CAPITATA VAR. ARCTOGENA | HEAD-LIKE SEDGE | MT. WASHINGTON |
| S1 | G? | | ST | CAREX CAPITATA VAR. ARCTOGENA | HEAD-LIKE SEDGE | THOMPSON & MESERVE' |
| S1 | G5T? | | | CAREX LENTICULARIS VAR ALBIMONTANA | LENS SEDGE | SHELBURNE |
| S2 | G5 | | ST | CASTILLEJA SEPTENTRIONALIS | PALE PAINTED CUP | THOMPSON & MESERVES |
| S2 | G5 | | ST | CASTILLEJA SEPTENTRIONALIS | PALE PAINTED CUP | GREENS GRANT |
| S2 | G5 | | ST | CIRCUS CYANEUS | NORTHERN HARRIER | DUMMER |
| S2 | G5 | | ST | CIRCUS CYANEUS | NORTHERN HARRIER | ERROL |
| S2 | G5 | | ST | CIRCUS CYANEUS | NORTHERN HARRIER | ERROL |
| S2 | G5 | | ST | CIRCUS CYANEUS | NORTHERN HARRIER | DUMMER |
| S2 | G5 | | ST | CIRCUS CYANEUS | NORTHERN HARRIER | ERROL |
| S2 | G5 | | | COREGONUS CLUPEAFORMIS | LAKE WHITEFISH | ERROL |
| S1SU | G3G4Q | | SE | CYNOGLOSSUM BOREALE | HOUND'S-TONGUE | SHELBURNE |
| S1 | G3 | 3C | SE | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | SHELBURNE |
| S1 | G5?Q | | SE | CYPRIPEDIUM PARVIFLORUM | SMALL YELLOW LADY'S-SLIPPER | SHELBURNE |
| S2 | G5 | | ST | CYPRIPEDIUM PUBESCENS | LARGE YELLOW LADY'S-SLIPPER | SUCCESS |
| S2 | G5 | | | DESCHAMPSIA ATROPURPUREA | MOUNTAIN HAIRGRASS | MT. WASHINGTON |
| S2 | G5 | | | DESCHAMPSIA ATROPURPUREA | MOUNTAIN HAIRGRASS | MT. WASHINGTON |
| S2 | G5 | | | DESCHAMPSIA ATROPURPUREA | MOUNTAIN HAIRGRASS | MT. WASHINGTON |
| S3 | G5 | | ST | DIAPENSIA LAPPONICA | LAPLAND DIAPENSIA | MT. WASHINGTON |
| S1 | G3G5 | | SE | DRABA LANCEOLATA | LANCEOLATE CRESS | SECOND COLLEGE GRAN |
| S1 | G5 | | ST | DRYOPTERIS FRAGRANS | FRAGRANT FERN | SECOND COLLEGE GRAN |
| S1 | G5 | | ST | DRYOPTERIS FRAGRANS | FRAGRANT FERN | SHELBURNE |
| S1 | G5 | | ST | DRYOPTERIS FRAGRANS | FRAGRANT FERN | RANDOLPH |
| S1 | G5 | | ST | DRYOPTERIS FRAGRANS | FRAGRANT FERN | SECOND COLLEGE GRAN |
| S1 | G5 | | ST | DRYOPTERIS FRAGRANS | FRAGRANT FERN | GORHAM |
| S2 | G4 | | ST | DRYOPTERIS GOLDIANA | GOLDIE'S FERN | PINKHAM'S GRANT |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | BEAN'S PURCHASE |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | MT. WASHINGTON |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | MT. WASHINGTON |

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|---|---|---|---|---|---|---|
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | MT. WASHINGTON |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | MT. WASHINGTON |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | THOMPSON & MESERVES |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | SHELBURNE |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | SHELBURNE |
| S2 | G5 | | ST | EMPETRUM ATROPURPUREUM | PURPLE CROWBERRY | BEAN'S PURCHASE |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | LOW AND BURBANK'S G |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | MT. WASHINGTON |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | MT. WASHINGTON |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | MT. WASHINGTON |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | MT. WASHINGTON |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | LOW AND BURBANKS GR |
| S3 | G5 | | ST | EMPETRUM NIGRUM | BLACK CROWBERRY | SUCCESS |
| S2 | G5 | | ST | EPILOBIUM CILIATUM | CILIATED WILLOW-HERB | RANDOLPH |
| S2 | G5 | | ST | EPILOBIUM CILIATUM | CILIATED WILLOW-HERB | DUMMER |
| S2 | G5 | | ST | EPILOBIUM HORNEMANNI | HORNEMANN'S WILLOW-HERB | MT. WASHINGTON |
| S2 | G5 | | ST | EPILOBIUM HORNEMANNI | HORNEMANN'S WILLOW-HERB | MT. WASHINGTON |
| S2 | G5 | | ST | EPILOBIUM HORNEMANNI | HORNEMANN'S WILLOW-HERB | MT. WASHINGTON |
| S2 | G5 | | ST | EPILOBIUM HORNEMANNI | HORNEMANN'S WILLOW-HERB | LOW AND BURBANKS GR |
| S1 | G5 | | ST | EQUISETUM PALUSTRE | MARSH HORSETAIL | ERROL |
| S1 | G5 | | ST | EQUISETUM PALUSTRE | MARSH HORSETAIL | STRATFORD |
| S2 | G5 | | ST | EQUISETUM PRATENSE | MEADOW HORSETAIL | GORHAM |
| S2 | G5 | | | EQUISETUM VARIEGATUM | VARIEGATED HORSETAIL | DIX'S GRANT |
| S1 | G4 | | SE | EUPHRASIA OAKESII | OAKES' EYEBRIGHT | MT. WASHINGTON |
| S1 | G4 | | SE | EUPHRASIA OAKESII | OAKES' EYEBRIGHT | MT. WASHINGTON |
| S2 | G4 | | ST | GEOCAULON LIVIDUM | NORTHERN COMANDRA | BEANS PURCHASE |
| S2 | G4 | | ST | GEOCAULON LIVIDUM | NORTHERN COMANDRA | SUCCESS |
| S2 | G4 | | ST | GEOCAULON LIVIDUM | NORTHERN COMANDRA | SHELBURNE |
| S1 | G5T5? | | SE | GERANIUM CAROLINIANUM VAR. CONFERTIFLO | CRANESBILL | SECOND COLLEGE GRAN |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | BEAN'S PURCHASE |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | PINKHAMS GRANT |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | THOMPSON & MESERVES |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | THOMPSON & MESERVES |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | SARGENT'S PURCHASE |
| S3 | G2 | 3C | ST | GEUM PECKII | MOUNTAIN AVENS | THOMPSON & MESERVES |
| S1 | G5 | | SE | GNAPHALIUM SUPINUM | MT. CUDWEED | MT. WASHINGTON |
| S1 | G5TU | | SE | HACKELIA DEFLEXA VAR. AMERICANA | BEGGAR'S-LICE | SECOND COLLEGE GRAN |
| S1 | G5? | | SE | HIERACIUM ROBINSONII | ROBINSON'S HAWKWEED | SECOND COLLEGE GRAN |
| S1 | G5? | | SE | HIERACIUM ROBINSONII | ROBINSON'S HAWKWEED | SECOND COLLEGE GRAN |
| S2 | G5 | | | HIEROCHLOE ALPINA | ALPINE SWEET GRASS | SARGENT'S PURCHASE |
| S3 | G5 | | ST | HIPPURIS VULGARIS | COMMON MARE'S-TAIL | CAMBRIDGE |
| S2 | G4 | | ST | ISOETES RIPARIA | RIVER BANK QUILLWORT | ODELL |
| S3 | G5 | | | LARUS ARGENTATUS | HERRING GULL | SUCCESS |
| S1 | G3 | C2 | SE | LISTERA AURICULATA | AURICLED TWAYBLADE | ATKINSON, GILMANTON |
| S2 | G5 | | ST | LISTERA CONVALLARIOIDES | LILY-LEAVED TWAYBLADE | DUMMER |
| S2 | G5 | | ST | LISTERA CONVALLARIOIDES | LILY-LEAVED TWAYBLADE | RANDOLPH |
| S2 | G5 | | ST | LISTERA CORDATA | HEART-LEAVED TWAYBLADE | MT. WASHINGTON |
| S2 | G5 | | ST | LISTERA CORDATA | HEART-LEAVED TWAYBLADE | THOMPSON & MESERVE' |
| S3 | G5 | | ST | LOISELEURIA PROCUMBENS | ALPINE AZALEA | MT. WASHINGTON |
| S2 | G5 | | SE | LUZULA CONFUSA | NORTHERN WOODRUSH | MT. WASHINGTON |
| S3 | G3G5 | | ST | LUZULA SPICATA | SPIKED WOODRUSH | MT. WASHINGTON |
| S3 | G3G5 | | ST | LUZULA SPICATA | SPIKED WOODRUSH | RANDOLPH |
| S2 | G5 | | ST | MALAXIS UNIFOLIA | GREEN ADDER'S-MOUTH | GORHAM |
| S2 | G5 | | ST | MALAXIS UNIFOLIA | GREEN ADDER'S-MOUTH | SHELBURNE |
| S2 | G5 | | ST | MALAXIS UNIFOLIA | GREEN ADDER'S-MOUTH | MILAN |
| S2 | G5 | | ST | MALAXIS UNIFOLIA | GREEN ADDER'S-MOUTH | SECOND COLLEGE GRAN |
| S1 | G5 | | ST | MARTES AMERICANA | MARTEN | DIXVILLE |
| S1 | G5 | | ST | MARTES AMERICANA | MARTEN | DIXVILLE |
| S1 | G5 | | ST | MARTES AMERICANA | MARTEN | DIX'S GRANT |
| S4 | G5 | | | MICROTUS CHROTORRHINUS | ROCK VOLE | GORHAM |

| | | | | | | |
|---|---|---|---|---|---|---|
| S4 | G5 | | | MICROTUS CHROTORRHINUS | ROCK VOLE | PITTSBURG |
| S2 | G5 | | ST | MILIUM EFFUSUM | MILLET-GRASS | SECOND COLLEGE GRAN |
| S4 | G5 | | | MINUARTIA GROENLANDICA | MOUNTAIN SANDWORT | MT. WASHINGTON |
| S4 | G5 | | | MINUARTIA GROENLANDICA | MOUNTAIN SANDWORT | SHELBURNE |
| S2 | G5 | | ST | MYRIOPHYLLUM FARWELLII VAR. AMERICANA | FARWELL'S MILFOIL | RANDOLPH |
| | | | | NNE ACIDIC CLIFF COMMUNITY | | RANDOLPH |
| | | | | NNE ACIDIC ROCKY SUMMIT/ROCK OUTCROP C | | MILAN |
| | | | | NNE ACIDIC ROCKY SUMMIT/ROCK OUTCROP C | | SHELBURNE |
| | | | | NNE CALCAREOUS CLIFF COMMUNITY | | GORHAM BERLIN |
| | | | | NNE CIRCUMNEUTRAL CLIFF COMMUNITY | | SECOND COLLEGE GRAN |
| | | | | NNE COLD-AIR TALUS FOREST/WOODLAND | | RANDOLPH |
| | | | | NNE DRY FOREST ON ACIDIC BEDROCK OR TI | | MILAN |
| | | | | NNE HIGH-ENERGY RIVERBANK COMMUNITY | | ATKINSON & GILMANTO |
| | | | | NNE LOWLAND SPRUCE/FIR FOREST | | SECOND COLLEGE GRAN |
| | | | | NNE MESIC HARDWOOD FOREST ON ACIDIC BE | | SHELBURNE |
| | | | | NNE RIVERSIDE OUTCROP COMMUNITY | | SECOND COLLEGE GRAN |
| SU | G5 | | SE | OSMORHIZA CHILENSIS | SWEET CICELY | DIX'S GRANT |
| SU | G5 | | SE | OSMORHIZA CHILENSIS | SWEET CICELY | RANDOLPH |
| SU | G5 | | SE | OSMORHIZA CHILENSIS | SWEET CICELY | GORHAM |
| SU | G5 | | SE | OSMORHIZA CHILENSIS | SWEET CICELY | GORHAM |
| S1 | G? | | ST | OXYRIA DIGYNA | MOUNTAIN SORREL | MT. WASHINGTON |
| S1 | G? | | ST | OXYRIA DIGYNA | MOUNTAIN SORREL | MT. WASHINGTON |
| S1 | G? | | ST | OXYRIA DIGYNA | MOUNTAIN SORREL | MT. WASHINGTON |
| S1 | G? | | ST | OXYRIA DIGYNA | MOUNTAIN SORREL | MT. WASHINGTON |
| S1 | G? | | ST | OXYRIA DIGYNA | MOUNTAIN SORREL | MT. WASHINGTON |
| S2 | G4 | 3C | ST | PANAX QUINQUEFOLIUM | GINSENG | SHELBURNE |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | SECOND COLLEGE GRAN |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | WENTWORTHS LOCATION |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | DUMMER |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | CAMBRIDGE |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | CAMBRIDGE |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | CAMBRIDGE |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | DUMMER |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | CAMBRIDGE |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | SECOND COLLEGE GRAN |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| S2 | G5 | | ST | PANDION HALIAETUS | OSPREY | ERROL |
| SU | G5T5 | | SE | PETASITES FRIGIDUS VAR. PALMATUS | SWEET COLTSFOOT | SUCCESS |
| S3 | G5 | | ST | PHLEUM ALPINUM | ALPINE TIMOTHY | MT. WASHINGTON |
| S2 | G5 | | | PHOXINUS NEOGAEUS | FINESCALE DACE | WENTWORTH'S LOCATIO |
| S2 | G5 | | | PHOXINUS NEOGAEUS | FINESCALE DACE | WENTWORTH'S LOCATIO |
| S2 | G5 | | | PHOXINUS NEOGAEUS | FINESCALE DACE | DUMMER |
| S2 | G5 | | | PHOXINUS NEOGAEUS | FINESCALE DACE | MILLSFIELD |
| S2 | G5 | | ST | PHYLLODOCE CAERULEA | MOUNTAIN-HEATH | MT. WASHINGTON |
| S2 | G5 | | ST | PINUS BANKSIANA | JACK PINE | ERROL |
| S2 | G5 | | ST | PINUS BANKSIANA | JACK PINE | ERROL |
| S2 | G5 | | ST | PINUS BANKSIANA | JACK PINE | CAMBRIDGE |
| S2 | G5 | | ST | PINUS BANKSIANA | JACK PINE | ERROL |

| | | | | | | |
|---|---|---|---|---|---|---|
| S2 | G5 | | ST | PINUS BANKSIANA | JACK PINE | ERROL |
| S3 | G3G5 | | SE | POA FERNALDIANA | WAVY BLUEGRASS | MT. WASHINGTON |
| S2 | G? | | SE | POA PRATENSIS SSP ALPIGENA | ALPINE MEADOW GRASS | MT. WASHINGTON |
| S2 | G5 | | | POTAMOGETON NODOSUS | KNOTTY PONDWEED | ERROL |
| S2 | G5 | | | POTAMOGETON NODOSUS | KNOTTY PONDWEED | ERROL |
| S1 | G2 | C2 | ST | PRENANTHES BOOTTII | BOOTT'S RATTLESNAKE-ROOT | SARGENT'S PURCHASE |
| S1 | G2 | C2 | ST | PRENANTHES BOOTTII | BOOTT'S RATTLESNAKE-ROOT | MT. WASHINGTON |
| S2 | G5 | | SE | PYROLA ASARIFOLIA | BOG WINTERGREEN | MILAN |
| S2 | G5 | | SE | PYROLA ASARIFOLIA | BOG WINTERGREEN | SHELBURNE |
| S2 | G3G5 | | ST | SAGITTARIA CUNEATA | WAPATO | ERROL |
| S2 | G3G5 | | ST | SAGITTARIA CUNEATA | WAPATO | RANDOLPH |
| S2 | G3G5 | | ST | SAGITTARIA CUNEATA | WAPATO | CAMBRIDGE |
| S1 | G4 | | ST | SALIX ARGYROCARPA | SILVER WILLOW | MT. WASHINGTON |
| S2 | G5 | | ST | SALIX HERBACEA | DWARF WILLOW | SARGENT'S PURCHASE |
| S2 | G5 | | ST | SALIX HERBACEA | DWARF WILLOW | THOMPSON AND MESERV |
| S2 | G5 | | ST | SALIX HERBACEA | DWARF WILLOW | SARGENT'S PURCHASE |
| S2 | G5 | | ST | SALIX HERBACEA | DWARF WILLOW | SARGENT'S PURCHASE |
| S2 | G5 | | ST | SALIX HERBACEA | DWARF WILLOW | MT. WASHINGTON |
| S2 | G5 | | ST | SALIX PELLITA | SATIN WILLOW | WENTWORTH'S LOCATIO |
| S2 | G5 | | ST | SALIX PELLITA | SATIN WILLOW | CAMBRIDGE |
| S2 | G5 | | ST | SALIX PELLITA | SATIN WILLOW | ERROL |
| S2 | G5? | | ST | SALIX PLANIFOLIA | TEA-LEAVED WILLOW | SARGENT'S PURCHASE |
| S2 | G5? | | ST | SALIX PLANIFOLIA | TEA-LEAVED WILLOW | SARGENT'S PURCHASE |
| S1 | G5? | | SE | SAXIFRAGA RIVULARIS | ALPINE BROOK SAXIFRAGE | MT. WASHINGTON |
| S1 | G5? | | SE | SAXIFRAGA RIVULARIS | ALPINE BROOK SAXIFRAGE | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| S1 | G? | | ST | SILENE ACAULIS VAR. EXSCAPA | MOSS CAMPION | MT. WASHINGTON |
| SU | G4G5 | | | SOLIDAGO CALCICOLA | ROCK GOLDENROD | BEAN'S PURCHASE |
| SU | G4G5 | | | SOLIDAGO CALCICOLA | ROCK GOLDENROD | BEAN'S PURCHASE |
| S4 | G5 | C2 | | SOREX DISPAR | LONG-TAILED OR ROCK SHREW | SECOND COLLEGE GRAN |
| S4 | G5 | C2 | | SOREX DISPAR | LONG-TAILED OR ROCK SHREW | BERLIN |
| SU | G4G5 | | | SPARGANIUM ANDROCLADUM | BUR-WEED | SECOND COLLEGE GRAN |
| S1 | G? | | SE | SPIRANTHES CASEI | CASE'S LADY'S-TRESSES | MILAN |
| S3 | G3 | | | VACCINIUM BOREALE | BOREAL BLUEBERRY | SHELBURNE |
| S3 | G5 | | ST | VACCINIUM ULIGINOSUM VAR. ALPINUM | BILBERRY | MT. WASHINGTON. |
| S1 | G? | | SE | VERONICA WORMSKJOLDII | ALPINE SPEEDWELL | MT. WASHINGTON |
| S1 | G? | | SE | VERONICA WORMSKJOLDII | ALPINE SPEEDWELL | MT. WASHINGTON |
| S2 | G5? | | ST | VIOLA PALUSTRIS | NORTHERN MARSH VIOLET | MT. WASHINGTON |
| S2 | G5? | | ST | VIOLA PALUSTRIS | NORTHERN MARSH VIOLET | MT. WASHINGTON |
| S1 | G5 | | SE | WOODSIA GLABELLA | SMOOTH WOODSIA | GORHAM |

THE RANKING SYSTEM DEVELOPED BY THE NATURE CONSERVANCY AND USED BY ALL STATE NATURAL HERITAGE PROGRAMS FOR "ELEMENTS" OF NATURAL DIVERSITY (RARE SPECIES AND EXEMPLARY NATURAL COMMUNITIES)

Each element is assigned a single global rank by specialists under the guidance of the national Science Department of The Nature Conservancy. State ranks within each state, in which the element occurs, are assigned by the state Heritage Program and will vary from state to state.

GLOBAL ELEMENT RANKS:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extinction. [Critically endangered throughout range.]

G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. [Endangered throughout range.]

G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state, a physiographic region) or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100. [Threatened throughout range].

G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.

G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

GA = Accidental in North America (not part of the established biota, usually a species of bird).

GE = An exotic species established in North America (e.g., Japanese Honeysuckle).

GH = Of historical occurrence throughout its range, i.e. formerly part of the established biota, with the expectation that it may be rediscovered (e.g., Ivory-billed Woodpecker).

The New Hampshire Natural Heritage Inventory does not inventory GA or GE species.

STATE ELEMENT RANKS:

- S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extirpation from the state. [Critically endangered in state.]
- S2 = Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extirpation from the state. [Endangered in state].
- S3 = Rare in state (on the order of 20+ occurrences). [Threatened in state].
- S4 = Apparently secure in state.
- S5 = Demonstrably secure in state.
- SA = Accidental in state, including species which only sporadically breed in state.
- SE = An exotic species established in state; may be native elsewhere in North America (e.g., house finch).
- SH = Of historical occurrence in the state with the expectation that it may be rediscovered.
- SU = Possibly in peril in state but status uncertain; need more information.
- SX = Apparently extirpated from state.

The New Hampshire Natural Heritage Inventory primarily inventories elements in the S1 and S2 categories plus several selected elements ranked S3.

Key to Status

NH Native Plant Protection Act: RSA 217-A:3,III (endangered plants) and RSA 217-A:3,XII (threatened plants). State protected animals: Fish & Game Rules Chapt. Fis 1000 Conservation of Endangered Species. Part Fis 1001.01 (endangered animals) and 1001.02 (threatened animals).

SE = State Endangered
ST = State Threatened

Federal Endangered Species Act, 1973. Public Law 93-205, as amended.

LE = Federally Endangered
LT = Federally Threatened
FC = Federal Candidate Species (includes C1, C2, 3C, etc.)
PE = Proposed Endangered
PT = Proposed Threatened

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph L. Ignazio, Chief
Planning Division
ATTN: Impact Analysis Branch
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

AUG 22 1988

Dear Mr. Ignazio:

This responds to your request, dated August 4, 1988, for information on the presence of Federally listed and proposed endangered or threatened species in connection with your initiation of reconnaissance investigations for development of flood damage reduction measures in flood prone areas in the Kennebec, Androscoggin, and Penobscot River basins in Maine; the Mascoma and Ashuelot River basins in New Hampshire; and the coastal breach at Nauset Beach in Chatham, Massachusetts.

The following endangered and threatened species are found within your proposed project areas and are shown below by state and general location.

Maine

Kennebec River Basin: Bald Eagles (Haliaeetus leucocephalus) nest and overwinter at a number of sites from Augusta south. The threatened Piping Plover (Charadrius melodus) nest and feed on coastal beaches.

Androscoggin River Basin: The headwater reaches have sites with a strong potential for nesting by Peregrine Falcons (Falco peregrinus).

Penobscot River Basin: Bald Eagles nest and overwinter throughout this river basin.

New Hampshire

Mascoma River Basin: No listed species

Ashuelot River Basin: The dwarf wedge mussel (Alasmidonta heterodon), soon to be proposed as an endangered species, is found below the Surrey Dam. Surveys of this basin for additional populations are underway.

Massachusetts

Nauset Beach, Chatham: Piping Plovers are known from this area and have nested on South Beach Island and North Beach. Potential nesting and feeding habitat exists throughout this area.

You may wish to contact Steve Timpano of the Maine Department of Inland Fisheries and Wildlife, 284 State Street, Augusta, Maine, at 207-289-5258; the Massachusetts Natural Heritage Program, 100 Cambridge Street, Boston, Massachusetts, at 617-727-9194; and the New Hampshire Department of Resource and Economic Development, P.O. Box 856, Concord, New Hampshire, at 603-271-3623 *for information on state listed species.*

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act.

Lists of Federally designated endangered and threatened species in New Hampshire, Massachusetts, and Maine are inclosed for your information. Thank you for your cooperation and please contact Mr. Roger Hogan of this office at 603-225-1411 if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Inclosure

Gordon E. Beckett
Supervisor
New England Area

| Common Name | Scientific Name | Status | Distribution |
|---|---|---|---|
| **FISHES:** | | | |
| Sturgeon, shortnose* | Acipenser brevirostrum | E | Kennebec River & Atlantic Coastal Waters |
| **REPTILES:** | | | |
| Turtle, leatherback* | Dermochelys coriacea | E | Oceanic summer resident |
| Turtle, loggerhead* | Caretta caretta | T | Oceanic summer resident |
| Turtle, Atlantic ridley* | Lepidochelys kempii | E | Oceanic summer resident |
| **BIRDS:** | | | |
| Eagle, bald | Haliaeetus leucocephalus | E | Entire state-nesting habitat |
| Falcon, American peregrine | Falco peregrinus anatum | E | Entire state-reestablishment to former breeding range in progress |
| Falcon, Arctic peregrine | Falco peregrinus tundrius | E | Entire state migratory-no nesting |
| Plover, Piping | Charadrius melodus | T | Entire state - nesting habitat |
| Roseate Tern | Sterna dougallii dougallii | E | Atlantic Coast |
| **MAMMALS:** | | | |
| Cougar, eastern | Felis concolor couguar | E | Entire state-may be extinct |
| Whale, blue* | Balaenoptera musculus | E | Oceanic |
| Whale, finback* | Balaenoptera physalus | E | Oceanic |
| Whale, humpback* | Megaptera novaeangliae | E | Oceanic |
| Whale, right* | Eubalaena spp. (all species) | E | Oceanic |
| Whale, sei* | Balaenoptera borealis | E | Oceanic |
| Whale, sperm* | Physeter catodon | E | Oceanic |
| **MOLLUSKS:** | | | |
| NONE | | | |
| **PLANTS:** | | | |
| Small Whorled Pogonia | Isotria medeoloides | E | York, Kennebec, Cumberland, Oxford Counties |
| Lousewort, Furbish's | Pedicularis furbishiae | E | Aroostook County |

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. 1/25/88

# FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW HAMPSHIRE

| Common Name | Scientific Name | Status | Distribution |
|---|---|---|---|
| **FISHES:** | | | |
| Sturgeon, shortnose* | Acipenser brevirostrum | E | Atlantic Coastal Waters |
| **REPTILES:** | | | |
| Turtle, leatherback* | Dermochelys coriacea | E | Oceanic summer resident |
| Turtle, loggerhead* | Caretta caretta | T | Oceanic summer resident |
| Turtle, Atlantic ridley* | Lepidochelys kempii | E | Oceanic summer resident |
| **BIRDS:** | | | |
| Eagle, bald | Haliaeetus leucocephalus | E | Entire state-migratory |
| Falcon, American peregrine | Falco peregrinus anatum | E | Entire state-reestablishment to former breeding range in progress |
| Falcon, Arctic peregrine | Falco peregrinus tundrius | E | Entire state migratory-no nesting |
| Plover, Piping | Charadrius melodus | T | Entire state migratery-nesting uncertain |
| Roseate Tern | Sterna dougallii dougallii | E | Atlantic Coast |
| **MAMMALS:** | | | |
| Cougar, eastern | Felis concolor couguar | E | Entire state-may be extinct |
| Whale, blue* | Balaenoptera musculus | E | Oceanic |
| Whale, finback* | Balaenoptera physalus | E | Oceanic |
| Whale, humpback* | Megaptera novaeangliae | E | Oceanic |
| Whale, right* | Eubalaena spp. (all species) | E | Oceanic |
| Whale, sei* | Balaenoptera borealis | E | Oceanic |
| Whale, sperm* | Physeter catodon | E | Oceanic |
| **MOLLUSKS:** | | | |
| NONE | | | |
| **PLANTS:** | | | |
| Jesup's milk-vetch | Astragulus robbinsii var. jesupi | E | Connecticut Rvr. Valley |
| Robbins cinquefoil | Potentilla robbinsiana | E | Coos County |
| Small Whorled Pogonia | Isotria medeoloides | E | Belknap, Strafford, Merrimack, Grafton, Carroll, Rockingham, Hillsborough Counties |

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. 1/25/88

# FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN MASSACHUSETTS

| Common Name | Scientific Name | Status | Distribution |
|---|---|---|---|
| **FISHES:** | | | |
| Sturgeon, shortnose* | Acipenser brevirostrum | E | Connecticut River & Atlantic Coastal Waters |
| **REPTILES:** | | | |
| Turtle, green* | Chelonia mydas | T | Oceanic straggler in Southern New England |
| Turtle, hawksbill* | Eretmochelys imbricata | E | Oceanic straggler in Southern New England |
| Turtle, leatherback* | Dermochelys coriacea | E | Oceanic summer resident |
| Turtle, loggerhead* | Caretta caretta | T | Oceanic summer resident |
| Turtle, Atlantic ridley* | Lepidochelys kempii | E | Oceanic summer resident |
| Turtle, Plymouth red-bellied | Chrysemys rubriventris bangsi | E | Plymouth & Dukes Counties |
| **BIRDS:** | | | |
| Eagle, bald | Haliaeetus leucocephalus | E | Entire state |
| Falcon, American peregrine | Falco peregrinus anatum | E | Entire state-reestablishment to former breeding range in progress |
| Falcon, Arctic peregrine | Falco peregrinus tundrius | E | Entire state migratory-no nesting |
| Plover, Piping | Charadrius melodus | T | Entire state - nesting habitat |
| Roseate Tern | Sterna dougallii dougallii | E | Atlantic Coast |
| **MAMMALS:** | | | |
| Cougar, eastern | Felis concolor couguar | E | Entire state-may be extinct |
| Whale, blue* | Balaenoptera musculus | E | Oceanic |
| Whale, finback* | Balaenoptera physalus | E | Oceanic |
| Whale, humpback* | Megaptera novaeangliae | E | Oceanic |
| Whale, right* | Eubalaena spp. (all species) | E | Oceanic |
| Whale, sei* | Balaenoptera borealis | E | Oceanic |
| Whale, sperm* | Physeter catodon | E | Oceanic |
| **MOLLUSKS:** NONE | | | |
| **PLANTS:** | | | |
| Small Whorled Pogonia | Isotria medeoloides | E | Hampshire, Essex Hampden, Worcester Middlesex Counties |
| Gerardia, Sandplain | Agalinus acuta | **PE | Barnstable County |

* Except for sea turtle nesting habitat, principal responsiblity for these species is vested with the National Marine Fisheries Service

** Potentially endangered

Rev. 1/25/88

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

DEC 2 1 1988

Dear Mr. Ignazio:

This planning aid letter is intended to provide a preliminary assessment of fish and wildlife impacts from potential flood control measures being evaluated by the New England Division for the flood protection reconnaissance study of the Androscoggin River Basin within Franklin, Oxford, and Androscoggin Counties, Maine and Coos County, New Hampshire. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

It is our understanding that the reconnaissance investigation focuses on three methods of providing flood control in the Basin: re-regulation of existing storage reservoirs in the basin, including the Rangeley Lakes System and several mainstem hydropower dams; development of new storage in several tributaries of the middle Androscoggin Basin; and development of a forecasting and early warning system. At this time, no specific proposals for reservoir re-regulation or new dam construction have been proposed by the NED. The reconnaissance study has focused on hydraulic modeling of the basin to evaluate the feasibility of re-regulation or new reservoir construction. Therefore this letter will serve primarily to identify the important fish and wildlife resources of the Basin and to point out the potential for resource impacts if specific structural or operational options are eventually proposed.

Non-structural flood control measures such as floodproofing buildings, flood insurance, and relocation of flood-prone structures (depending on the site where the structures are relocated to) usually do not cause significant adverse impacts to fish and wildlife resources. We prefer non-structural flood control measures due to their low level intensity of adverse impacts.

DESCRIPTION OF PROJECT AREA

The Androscoggin River Basin lies in western Maine between the Saco River Basin to the west and the Kennebec River Basin to the east. The River originates in New Hampshire at the outlet of Umbagog Lake, just below the confluence with the Magalloway River. It flows south and east approximately 169 miles where it merges with the Kennebec River at Merrymeeting Bay in Maine. The total area of the Basin is approximately 3450 square miles, 80 percent of which lies in Maine, 20 percent in New Hampshire. The upper basin above Rumford is forested and mountainous. The basin below Rumford is less mountainous and contains more ponds and agricultural land. Elevations in the basin range from the 6288-foot Mount Washington in the headwaters to sea level at Brunswick where the river becomes tidally influenced.

Flows in the Androscoggin River are regulated from the Rangeley Lakes, a series of modified natural lakes in the headwaters. The Rangeley Lakes include: Kennebago Lake, Rangeley Lake, Mooselookmeguntic Lake, Upper and Lower Richardson Lakes, Aziscohos Lake, and Umbagog Lake. Storage capacity of the lakes has been increased by outlet control structures, originally used for log drives in the late 19th century. The reservoirs are owned and operated by the Union Water Power Company (UWP), a subsidiary of Central Maine Power Company (CMP) and the Androscoggin Reservoir Company (ARCo), comprised of several downstream water users, including CMP. There is currently hydropower generation at Aziscohos Dam and Errol Dam. There is a pending Federal Energy Regulatory Commission (FERC) proceeding to license Middle Dam as a storage project. Fish and wildlife mitigation measures are currently being developed at Middle, Aziscohos, and Errol dams under the statutory requirements of the FERC licensing process.

Spring runoff is captured in the Rangeley Lakes and released over the remainder of the year to provide flows for downstream water users. Flow releases are in accordance with an agreement between the owners of the storage reservoirs and downstream water users that has been in effect since 1909. The agreement calls for a constant flow of not less than 1550 cfs to be provided in the river at Berlin, N.H. and that the reservoir system be operated such that one third of the seasonal storage draw be from Aziscohos Lake, and two thirds from the other lakes. Water releases are used primarily for hydropower generation and industrial purposes. Although storage releases augment natural flows in the river, this does not necessarily result in fishery habitat enhancement, as demonstrated by instream flow studies recently completed at the Pontook Hydropower Project.

The Androscoggin River flows through many run-of-river hydropower projects at and below Berlin, N.H. There is no appreciable storage in the system until Gulf Island Dam (FERC No. 2283), located just upstream of Auburn, Maine. Gulf Island Pond serves as a re-regulation reservoir for a number of downstream hydropower projects. It is operated in a weekly cycling mode with reservoir refill on the weekends. Studies to assess fish and wildlife impacts and develop mitigation measures are currently underway as part of the FERC relicensing process for Gulf Island Dam.

Vegetation

The upper Androscoggin River Basin in the Rangeley Lakes Region contains extensive softwood, hardwood, and mixed timber stands. Timber harvesting is the primary land use with balsam fir, red spruce and yellow birch among the important commercial tree species. Other species found along the lake shores include white and red pine, aspen, white and gray birch, sugar maple, striped maple, mountain ash, larch, white cedar, black spruce, and hemlock. In the lower portions of the basin, species such as northern red oak, silver and red maple, ash, and beech are more common. Extensive vegetative inventories could not be completed due to the absence of leaf cover and the presence of snow during our November 1988, field reconnaissance.

The shoreline of the Rangeley Lakes is generally rocky with upland vegetation extending to the waters edge. Wetlands can be found at all of the lakes, however, wetland distribution varies widely. Lake water level fluctuation is a major factor limiting emergent wetland formation in the Rangeley Lakes. With the exception of Umbagog Lake, emergent wetlands are primarily found in the lower energy environments within coves or at the mouth of tributaries, e.g., Metallak Brook on Upper Richardson Lake and South Bog Stream on Rangeley Lake. Wetland plants observed included: sedges (Carex spp.), rushes (Juncus spp.), bulrushes (Scirpus spp.), cattail, spike-rush, sensitive fern, horsetail, and grasses. Although somewhat limited in distribution, these emergent wetland areas provide important habitat for wildlife, particularly loon and waterfowl nesting.

Shrub-scrub wetlands are found locally in narrow bands around the perimeter of the Rangeley Lakes. Woody wetland plants observed included: willow, wild raisin, red-osier dogwood, leather-leaf, labrador tea, sweet gale, bog rhododendron, spirea, arrowwood, Ilex, alder, Kalmia, elderberry, and blueberry.

Umbagog Lake differs from the other Rangeley Lakes as it is shallow (19-foot maximum depth) and includes extensive emergent wetlands and sphagnum bogs. This unique wetland complex is of significant regional importance for wildlife. Principle emergent wetland plants are spike-rush, burreed, sedges, arrowhead, and wild rice. Wooded bog plants include sphagnum, sweet gale, leather-leaf, labrador tea, alder, wild raisin, mountain holly, red maple, white cedar, and larch. Floating Island, on the northeast shore, has been designated a National Natural Landmark.

Wetlands are found throughout the middle portions of the Androscoggin River Basin encompassed by the reconnaissance study. Shrub-scrub wetlands occur along the rivers edge at most of the mainstem impoundments. Fringes of emergent wetland can also be found in some of the mainstem impoundments. All four of the tributaries under consideration for new storage reservoirs, i.e., the Webb, Ellis, Dead, and Little Androscoggin Rivers, have significant wetland areas within their drainages. Most of the headwater lakes and ponds, particularly Webb Lake and Androscoggin Lake, have peripheral wetlands that are important for wildlife. Gulf Island Pond has limited associated wetlands as a result of its pronounced water level fluctuations. Habitat evaluation studies are underway as part of the FERC relicensing process to quantify the effect of water level fluctuations on wetland and wildlife communities at the Gulf Island Dam Project.

## Fishery Resources

### Rangeley Lakes

The Rangeley Lakes are one of the most important fishing regions of inland Maine. Kennebago, Rangeley, Upper and Lower Richardson, Mooselookmeguntic, and Aziscohos support similar fish species, with natural populations of native brook trout and landlocked salmon being the most important. Kennebago, Rangeley, and Mooselookmeguntic have the best fisheries for these species, due to the availability of excellent spawning tributaries and the fact that these lakes have the lowest relative water level fluctuations. Richardson Lakes offer a high quality fishery also, however growth rates for salmon are somewhat lower, possibly due to greater water level fluctuations.

Lake trout have been introduced into the Richardson Lakes and are currently being managed by the Maine Department of Inland Fisheries and Wildlife. Apparently lake trout have not reproduced successfully in the lake, presumably due to water level fluctuations that exceed the reproductive tolerance of the species. This is presently not considered a problem as it allows the state to carefully manage the species by stocking, without fear of excessive competition with native salmonid species.

Aziscohos Lake has the poorest cold water reservoir fishery relative to the other upper lakes. This is due to extreme water level fluctuations and poor water quality in the summer months resulting from stratification and low dissolved oxygen levels. Salmonids move out of the Aziscohos Lake and into the Magalloway River and other tributaries during the late summer months to seek refuge from stressful water quality conditions.

Adult trout and salmon feed heavily on rainbow smelt and other forage species found in the Rangeley Lakes. In addition to smelt, other non-salmonid species recorded in the reservoirs include: common and northern sucker, lake chub, black-nosed dace, fallfish, creek chub, northern dace, fine-scale dace, red-bellied dace, black-nosed shiner, common shiner, fat-headed minnow, and sculpin. Brown trout have been introduced and are rare.

Umbagog Lake is much shallower than the other Rangeley Lakes and supports both warm and cold water fisheries. Warm water species include yellow perch, chain pickerel and brown bullhead (hornpout). In the deeper portions of the reservoir, near the outlet of the Rapid River, brook trout and landlocked salmon can be found.

Many of the tributary streams in the Rangeley Lakes offer excellent spawning and rearing habitat for salmonids and smelt. Most of the lake fisheries are supported by natural reproduction from these tributaries. We observed several salmon pairs spawning in the Rangeley River at the outlet of Rangeley Lake during our November 1, 1988, site visit. Smelt runs generally occur during April and May.

One of the most significant fishery management issues in the lakes is maintenance of free passage into spawning and refuge tributaries. As a result of annual lake drawdown, shallow deltas are exposed at some stream mouths, e.g., Metallak Brook in Upper Richardson. With severe reservoir drawdowns, upstream fish passage may be affected by: shallow water depths over the delta deposits; waterfall barriers; and/or increased exposure to predation. Access to spawning tributaries is currently being studied as part of the licensing of Middle Dam.

Mainstem Androscoggin River

The mainstem Androscoggin River above Berlin offers excellent habitat for warm and cold water fisheries, primarily brook trout, brown trout, rainbow trout, landlocked salmon, chain pickerel, yellow perch, and smallmouth bass. The New Hampshire Department of Fish and Game annually stocks brook, brown, and rainbow trout in the vicinity of the Pontook Hydroelectric Project. Below Berlin, the rainbow trout fishery is maintained to some degree by natural reproduction.

Tributaries in the middle Androscoggin Basin such as the Webb and Ellis Rivers support a combination of cold and warm water fisheries. Salmonids such as brook trout, brown trout, and landlocked salmon are found in the headwaters and seasonally in the lower rivers. Smallmouth bass are the primary warmwater species in the middle basin tributaries. Largemouth bass are found in lower reaches of the study area, e.g., Gulf Island Pond.

Presently, anadromous fish in the Androscoggin River are confined to the reach below Lewiston Falls, the historical limit of anadromous species except Atlantic salmon. Maine is currently in the process of restoring anadromous fish runs in the Androscoggin Basin. Since 1983, alewives, American shad, and Atlantic salmon have been trapped at the Brunswick dam and trucked to mainstem and tributary sites below Lewiston Falls. The only area in the reconnaissance study that is currently utilized by anadromous fish is the Little Androscoggin River. The Department of Marine Resources is currently stocking alewives in lakes and ponds throughout the Little Androscoggin Basin. Maine DMR will be planting shad in the basin as they are collected at Brunswick or transferred from other rivers. Factors limiting anadromous restoration in the Little Androscoggin River are the number of existing dams in the basin, water quality, and competition with resident fisheries.

## Wildlife Resources

The Rangeley Lakes region is relatively undeveloped and provides high quality habitat for a variety of wildlife species. White-tailed deer are one of the most important game species in the area. Moose are also common. Other mammals likely to occur in the study area include: black bear, coyote, red fox, bobcat, fisher, marten, weasel, river otter, mink, raccoon, striped skunk, muskrat, beaver, porcupine, snowshoe hare, red squirrel, and small mammals such as shrews, mice and voles. Furbearers are conspicuously uncommon in all of the Rangeleys except for Lake Umbagog. This is due to adverse consequences of lake level fluctuations which prohibits the growth of aquatic vegetation (food and cover) and prevents animal dens from being established at the waters edge.

Animals seen during our November site visit include bobcat, moose, common loon, bufflehead, common merganser, hooded merganser, bluejay, snow bunting, junco, chickadee, ruffed grouse, great blue heron, red squirrel, red-tailed hawk, osprey, Cooper's hawk, raven, crow, and ring-billed gull.

A number of unique wildlife areas are found in the Rangeley Lakes region. There is a very high quality wetland complex at the outlet of Kennebago Lake that supports excellent waterfowl production. The Kennebago River has been designated a Class "B" river in the Maine Rivers Study, denoting outstanding statewide resource values. Resource values specifically identified in the Study include: high quality wetlands important to waterfowl and furbearers; a major white-tailed deer wintering area near the mouth of Kamankeag Stream; and one of Maine's most outstanding inland fishing rivers for native brook trout and landlocked salmon.

The Rapid River, which flows six miles from Middle Dam to Umbagog Lake, has also been designated a Class "B" river in the Maine Rivers Study. Outstanding resource values include: a major deer wintering area along the river; important loon nesting islands at the mouth of the river in Umbagog Lake; significant brook trout and landlocked salmon resources; and one of the highest quality and most popular white water boating runs in the state. The Rapid River White Water Rapids are also designated as a State Registered Critical Area (#458) due to the high white water boating values and presence of a unique old-growth white pine stand along its banks. This stand is the largest stand of virgin pine and has the largest average tree size of any pine stand in the state.

Umbagog Lake was included in the Fish and Wildlife Service's 1979 Unique Ecosystem Concept Plan. The lake is considered one of the finest waterfowl areas in New Hampshire and is one of the most important breeding grounds for common loon in the northeast. Loon breeding habitat here is considered to be significant and unique due to the high habitat diversity and lack of disturbance. There are over 8000 acres of prime black duck nesting habitat within the Umbagog Lake wetland complex. Other waterfowl species that commonly breed in and around the reservoir include: goldeneye, ring-neck duck, wood duck, hooded merganser, and common merganser. Ruffed grouse, snipe, and woodcock are among the important upland game birds in the area. There is a great blue heron rookery that supports 20 to 30 heron pairs. There are six active osprey nests and one inactive bald eagle nest. Umbagog Lake has the only breeding colony of ring-billed gulls in Maine. It is the one reservoir in the Rangeley Lakes area that supports significant populations of furbearers, due primarily to more stable water levels which allow aquatic vegetation to flourish.

Both Aziscohos and Richardson Lakes also have heron rookeries. The rookery on Aziscohos is on an island and could be affected if water levels are increased, causing the nesting trees to die.

All of the Rangeley Lakes have resident loons. Attention has been focused on the Aziscohos Lake loon population as part of the FERC license proceedings. A comprehensive study of loon nesting documented 26 resident loons on the lake. Ten nesting pair were recorded in 1987. The primary factor limiting loon production on all of the reservoirs is water level fluctuations during the critical nesting period. Loons must nest at the waters edge since their body is adapted for swimming and they cannot walk upright on land. A rise in lake water levels as little as 0.5 feet can inundate the nest and destroy the clutch. Decreasing water levels expose shoreline between the nest and the waters edge, and thus prevent the birds from reaching the nest to protect and incubate the eggs. The effect of declining water levels is dependent on the slope of the shoreline. Drops of 1.5 vertical feet or less can be sufficient to prevent access by adult birds and thus cause nest failure. Because of the severe consequences of lake level fluctuation, artificial loon nesting islands are being experimentally evaluated as a condition of the Aziscohos Dam FERC license. There are many site-specific factors that affect the potential success of artificial nesting islands. Generally, they are considered to be of limited usefulness in mitigating the adverse effects of water level fluctuation.

Furbearer use was evident at all of mainstem and tributary sites in the reconnaissance study. There is an active beaver lodge just upstream of the upper dam in Berlin and beaver sign was visible in the dense alder-aspen cover along the river.

Androscoggin Lake, the source of the Dead River, is important for wildlife, particularly furbearers and birds. The lake receives significant waterfowl use, attracting species such as redheads and pintails that are not commonly found on other lakes in the region. Perimeter wetlands, especially those at the lake outlet, are important for waterfowl and loon production. Lothrup Island supports a major heron rookery, as well as an active osprey nest and an inactive bald eagle nest.

In accordance with Section 7 of the Endangered Species Act of 1973, as amended, (16 U.S.C 1561, et seq.), the Corps of Engineers is required to assure that their actions have taken into consideration impacts to Federally listed or proposed threatened or endangered species for all Federally funded, constructed, permitted, or licensed projects. The Corps responsibility to address impacts to threatened and endangered species associated with Federal projects is described in Sections 7(a) and (c) of the Endangered Species Act of 1973, as amended.

We have determined that listed species may be present within the proposed project area. In our August 22, 1988, letter to the New England Division we noted that the headwater reaches of the Androscoggin River Basin have sites with a strong potential for nesting by Peregrine falcons. Potential aerie sites are near the mainstem river in the Gilead-Bethel vicinity. Also, the project area includes two historic bald eagle nests that could potentially be used again in the future. These are located at Umbagog Lake and Androscoggin Lake. We may be able to provide more detailed endangered species information once a specific project proposal is available for review. We would recommend that in the interim you contact Mr. Steve Timpano, Environmental Coordinator of the Maine Department of Inland Fisheries and Wildlife, at 284 State Street, Augusta, Maine, 207-289-5258; and Mr. Hank Tyler of the Maine Critical Areas Program, State Planning Office, State House Station 38, Augusta, Maine, 207-289-3261, for information on species of state concern.

POTENTIAL PROJECT IMPACTS

All of the methods under investigation for flood control in the Androscoggin River Basin have the potential to cause significant adverse impacts to fish and wildlife resources. Some impacts may be more easily mitigable than others. There is limited potential for fish and wildlife benefits from these flood control measures. Flow augmentation is occurring under the present operating regime and does not necessarily enhance habitat for all fish species and lifestages. Instream flow releases and lake level management are currently being addressed in the FERC licensing process for several of the projects.

## Re-regulation of the Rangeley Lakes System

The Rangeley Lakes are currently managed to store runoff and snowmelt during the spring months for gradual release during the summer and fall to provide uniform flow conditions in the mainstem Androscoggin River for downstream power and industrial water users. Incidental benefits from the current operational regime include flood control for the valley below Errol and augmented flow conditions for whitewater boating and fishing during the natural low flow period.

While no specific proposals have been developed yet by NED, we assume that re-regulation to increase flood storage capabilities would possibly involve one or more of the following: increasing annual lake drawdowns to provide additional storage; surcharging the reservoirs or increasing the height of water control structures to provide additional storage; and/or changing reservoir refill/drawdown sequencing to provide additional storage capacity during peak runoff events.

Water level fluctuation in the Rangeley Lakes is presently a major factor affecting fish and wildlife productivity. Impacts from increasing the magnitude of annual water level fluctuations would include the following:

1. Increasing the drawdown could affect fish passage into spawning and refuge tributaries during low water conditions. As lake levels recede, tributary flow may become spread out over broad alluvial deposits or pass over waterfalls at stream mouths. Fish attempting to move upstream could be subjected to shallow water depths, impassable falls, higher temperatures, and/or predation. This is a critical issue since the salmonid and smelt fisheries are supported almost exclusively by natural production in lake tributaries. Access to cold water refuge habitat in lake tributaries is also critical for salmonids in Aziscohos Lake where water quality may become stressful by the end of the summer. Specific stream surveys during low water periods would be necessary to quantify the extent of this problem at each reservoir.

2. Additional lake drawdown could affect the aquatic food base for fish by reducing the area of productive littoral zone available for invertebrate food production. In addition to insects, other aquatic invertebrates such as freshwater clams and mussels may be adversely affected by increased littoral zone exposure.

3. Increasing the magnitude of lake level fluctuations could exacerbate conditions that presently affect lake trout spawning in the Richardson Lakes. While not a problem at this time, future management opportunities for natural lake trout production may be adversely affected.

4. Reductions in lake levels could affect water quality by changing stratification characteristics. Changes in water quality parameters such as temperature and dissolved oxygen could affect downstream riverine fisheries as well as reservoir fish resources.

5. Waterfowl and loon nesting/brooding activities could be severely affected by increased water level fluctuations. Surcharging the reservoirs during the spring runoff period could flood either newly established nests or traditional nesting sites. Permanently raising reservoir levels would also flood traditional nesting sites. New nesting sites may be limited at a higher pool level due to steep, rocky and wooded lake shores. Increasing reservoir drawdown during the spring and early summer months would decrease loon production by making their nest sites inaccessible. Waterfowl production may be similarly affected. Brood habitat would be impacted by reduced littoral productivity and nearshore cover availability.

6. Reduced lake water levels could have adverse consequences for emergent wetland and rooted aquatic vegetation in the Rangeley Lakes. Effects from wetland plant losses would extend beyond those animals dependent on these plants for food and cover. The loss of vertebrate and invertebrate prey organisms associated with aquatic plant communities would affect the entire food web.

7. Permanent increases in lake water levels could flood out cedar swamp deer yards. Increased water levels could also kill live nest trees in heron rookeries. The island rookery on Aziscohos Lake may be particularly vulnerable to flooding.

8. Lake level changes in Umbagog Lake could affect the unique floating bog communities there, including Floating Island, a National Natural Landmark administered by the National Park Service.

9. Changes in the reservoir fill schedule could affect instream flow releases below the dams. Negotiations over instream flow releases will be underway at Aziscohos Dam and Middle Dam as part of the FERC licensing process. Instream Flow Incremental Methodology (IFIM) flow studies have been conducted at both projects, and will be the basis for specific flow recommendations. Any changes in the lake flow releases will have to be made within the framework of the instream flow levels eventually adopted as license conditions for these projects.

<u>New Storage Reservoirs</u>

We assume that development of new storage capacity in the basin would involve construction of new flood control reservoirs. Detailed impact analyses cannot be provided until specific project plans have been formulated for review. All of the basins identified as potential sites for new storage support significant fish and wildlife resources. The Little Androscoggin Basin also supports anadromous fish resources. General impacts associated with development of new storage reservoirs would include the following:

1. There would be permanent habitat loss from the construction of dams, access roads, maintenance facilities, and containment dikes. There would be significant habitat changes associated with clearing the storage area. Maintenance of the storage area in an early successional stage would essentially eliminate the existing terrestrial and aquatic habitat values associated with streamside wetlands and riparian forest. High quality agricultural lands that are valuable to wildlife may also be affected by reservoir clearing. Physical habitat changes can also be expected from the impoundment of water behind the dams. The magnitude of habitat impacts will depend on the area flooded and water residence time. Temporary flooding can cause both direct mortality of vegetation or delayed mortality from chronic water stress. Plant communities would eventually change with the imposition of different ground and surface water regimes. New wetlands may eventually develop where water is ponded.

2. Impacts to wildlife would not necessarily be limited to the acreage of habitat cleared or flooded. Entire populations of animals in a basin could be affected by the loss of cover along seasonal migration routes traditionally provided by riparian corridors. The loss of seasonal foraging habitat would similarly affect animal populations that are not year-round residents in the impact zone.

3. Fishery habitat values would change, and possibly increase as a result of low flow augmentation on tributary streams. However, existing fishery resources in the impact zone would generally be negatively affected by new flood control reservoirs. Among the direct aquatic habitat impacts would be the loss of cover, shade, and terrestrial food inputs from the removal of streamside vegetation in the impoundment zone. Substrate suitability for spawning and food production could be reduced as a result of sediment deposition behind the dam. Additional sediment sources may develop from the loss of vegetative cover and periodic flooding of the impoundment area. Increased sediment levels can adversely affect fish eggs, fish gills, and can reduce habitat quality by filling in pools and smothering productive riffles.

4. Impacts to aquatic habitat downstream of the impoundments would also be expected. Substrate suitability for spawning and food production may be reduced if gravel recruitment is interrupted by the dams. Water turbidity

and sediment levels may increase if fine material accumulated behind the dams is transported downstream with the release of stored flood waters. Impoundments may also increase water temperatures and reduce dissolved oxygen levels due to organic loading, stratification, and/or loss of physical aeration.

5. Fishery habitat could be affected by instream flow changes upstream and downstream of the dams. In the impoundment areas, free flowing riverine habitat would be converted to slow moving lake habitat during periods of water storage. This problem would be particularly pronounced in the Little Androscoggin River Basin where free flowing riffle-run habitat is severely limited as a result of past dam construction. Natural flow levels below the dams would be decreased during periods of storage and increased when stored water is released. Fluctuating flow levels can cause fish stranding, redd dewatering, and can affect habitat levels for all life stages of fish. We recommend that detailed instream flow investigations using assessment techniques such as the Fish and Wildlife Service's *Instream Flow Incremental Methodology and/or the Habitat* Evaluation Procedures be conducted to evaluate flow-related impacts and develop mitigative measures for any new storage reservoirs.

6. Dam construction would also impact fish passage. At this time, the Little Androscoggin is the only basin under consideration for new storage where passage for anadromous species (alewives, potentially shad) would be required. Once specific storage proposals are developed, there should be additional coordination with the Maine fishery agencies and the Service regarding restoration plans for the area. Anadromous fish restoration may be affected even with state-of-the-art fish passage facilities, since no facility is completely effective. The incremental cumulative effect of additional dams may prove unacceptable to fishery management agencies. It is also possible that fish passage for inland species such as brook trout or landlocked salmon may be required if there is seasonal migration within the affected system.

Early Warning and Forecasting System

With the exception of Gulf Island Dam, the mainstem hydropower dams being evaluated in this reconnaissance study have limited storage capacity. It is our understanding that for them to be useful for flood control, their regulation would have to be linked to a forecasting and early warning system. Presumably with advance warning of a severe storm event, the mainstem ponds could be drawn down at short notice to dampen flood surges.

Wildlife that could be affected by drawdowns at the mainstem storage projects include furbearers and waterfowl that utilize fringe wetland habitats. The level of impact would depend on the time and duration of the drawdown. Potential effects on fishery resources would include fish stranding and redd dewatering from sudden drops behind the dams. Downstream effects could include redd scouring and water quality impacts from the release of sediments and/or contaminants accumulated behind the dams.

Fish and wildlife impacts have been documented as a result of routine water level fluctuations at Gulf Island Dam, the lower-most dam included in the reconnaissance study. Gulf Island Dam is operated by CMP and UWP as a re-regulating reservoir in conjunction with Deer Rips and several other downstream hydropower projects. Water level fluctuations vary from 4 to 8 feet during the weekly recycling period, depending on runoff conditions. The reservoir is gradually drawn down during the week, then outflow is shut off to allow the reservoir to refill on the weekends. These fluctuations have a negative impact on warm water fish and waterfowl production by limiting the development of rooted aquatic plants and other wetland vegetation. The reservoir also affects downstream fisheries by dewatering habitat (there presently is no minimum flow requirement) and degrading water quality, primarily reduced D.O. levels from oxygen deficient flow releases.

As part of the FERC relicensing process for the Gulf Island-Deer Rips Project, an Impoundment Water Level Management Study is currently underway that includes both Habitat Evaluation Procedure (HEP) and IFIM studies. The goal of these and other related studies is to develop a comprehensive fish and wildlife mitigation package, including minimum flow releases, to protect downstream fisheries. Flood control measures should be compatible with the mitigation plan eventually incorporated into the FERC license for the Gulf Island Project.

Nonstructural Measures

The use of nonstructural measures to prevent flood damage would, for the most part, not impact fish and wildlife resources. The only possibility of habitat degradation from nonstructural measures would be if houses or other structures were relocated in wetlands or other undeveloped wildlife habitat.

SUMMARY

All of the methods under consideration for flood control in the Androscoggin River study area have the potential to cause adverse impacts to fish and wildlife resources, particularly additional regulation of reservoir levels in the Rangeley Lakes. We recommend that nonstructural measures be investigated to accomplish flood control objectives within the Basin wherever possible because they offer a solution that is the least damaging to existing and planned fish and wildlife resources.

Potential impacts associated with increased regulation of the lakes and reservoirs in the Basin include: impacts to loon and waterfowl production from nest site inundation and/or isolation from drawdown; impacts to avian brood habitat from the loss of submerged and emergent wetland plants and associated prey; impacts to fish production by impairing access to refuge and spawning streams; reduction in fish growth from reduced insect and food fish production; and impacts to downstream fishery resources from changes in flow releases and water quality.

Potential impacts from new reservoir construction include: the loss of wildlife habitat from inundation and construction of dams, roads, other appurtenant facilities; the conversion of free flowing riverine habitat to slow moving reservoir habitat; interruption of bedload transport; blockage of fish passage; and water quality impacts from slowing and heating water in the impoundment. Although new reservoirs may enhance habitat for some warm water fish species, any gains in habitat values would not be consistent with present or future fishery management objectives.

Impacts from drawing down the mainstem reservoirs to provide instantaneous storage for individual storm events could include: disruption of furbearer and waterfowl nesting along the riverbanks; scouring or dewatering of redds; fish stranding; and flushing of accumulated sediments and/or contaminants.

Study Needs

If the project continues to the feasibility phase, studies will be needed to address each of the issues identified in the potential impacts section of this letter. Due to the complexity of issues surrounding regulation of the Rangeley Lakes, substantial coordination with all involved resource managers, users and advocates will be necessary. A more detailed review of existing literature should be performed to identify specific resource data needs. There may be a need for specific fish and wildlife inventory data for those sites where FERC-related or other studies have not been completed. Habitat evaluations for affected species should be performed to assess the full impact on fish and wildlife. Such studies would include, but not be limited to: a survey and inventory of critical wildlife use areas and wetlands affected by the project; an evaluation of affected terrestrial and aquatic habitat, preferably using the Service's Habitat Evaluation Procedures; development of fish passage facilities at new dams if required; instream flow studies using the Instream Flow Incremental Methodology; and development of mitigation measures.

Thank you for the opportunity to provide these planning aid comments. If you have any questions regarding this letter, please contact Michael Tehan of my staff at (603) 225-1411 or FTS 834-4411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

John R. McKernan, Jr.
*Governor*

Nathaniel H. Bowditch
*Commissioner*

**Department**
**of**
**ECONOMIC AND COMMUNITY DEVELOPMENT**

March 22, 1989

Mr. Joseph L. Ignazio
Department of the Army, New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

RE: Androscoggin River Basin

Dear Mr. Ignazio,

Recently, the Natural Heritage Program was transferred from The Nature Conservancy to the Office of Comprehensive Planning in DECD as part of an agreement to coordinate information management between the Critical Areas Program and the Heritage database. Our goal is a prompt reply to requests about rare and endangered species, natural communities and registered Critical Areas. As such, your request to the Critical Areas Program was forwarded to us for initial processing.

I have checked the Natural Heritage database in response to your request of 23 January 1989 regarding rare vascular plants, Critical Areas, and other rare natural features in the vicinity of the Androscoggin River Basin in Maine.

The data base includes animals, plants, and natural communities that are endangered, threatened, or considered rare in Maine. Many occurrences have been reported for the location mentioned above (see list on next page). For more detailed information about any Critical Areas appearing on the enclosed list, please contact Trish DeHond or Hank Tyler, Critical Areas Program, State Planning Office, State House Station 38, Augusta, Maine 04333, (207) 289-3261.

In addition to the above, we have on file historical records for several species (occurences not seen within the last 15 years). The information on the historical records is recorded from the museum labels of the species which were collected. The location information is not specific, but indicates that these species could have been collected from the area you are reviewing. These records have not been confirmed by Natural Heritage Program staff and may exist within the project boundary.

State House Station ~~59~~ 130, Augusta, Maine 04333 — *Offices Located at* ~~193 State Street~~ 219 Capitol St.
Telephone (207) 289-~~2656~~ 6800

The enclosed list includes the names of the species and their state and federal status (where applicable). This list can serve as a guideline for field work conducted for this project review.

A flood control project in the area could destroy one or more of these occurrences.

The Natural Heritage Program has compiled data on Maine's rare, endangered, or otherwise significant plant and animal species, plant communities, and geological features. While this information is available for preparation and review of environmental assessments, it is not a substitute for on-site surveys. The quantity and quality of data collected by the Natural Heritage Program are dependent on the research and observations of many individuals and organizations. In most cases, information on natural features is not the result of comprehensive field surveys. For this reason, the Maine Natural Heritage Program cannot provide a definitive statement on the presence or absence of unusual natural features in any part of Maine.

The Natural Heritage Program welcomes coordination with individuals or organizations proposing environmental alteration, and/or conducting environmental assessments; however, the information, or lack thereof, provided by the Natural Heritage Program should never be regarded as a complete statement on the elements of natural diversity being considered. If data provided by the Natural Heritage Program are to be published in any form, the Program should be informed at the outset and credited as the source.

Please take note that the Maine Department of Inland Fisheries and Wildlife has statutory authority for birds, mammals, reptiles, amphibians and fishes. This agency should be notified to insure a complete review of the project area. Their address is State House Station 17, Augusta, Maine, 04333.

Thank you for using the Natural Heritage Program as part of your environmental review procedure. Please do not hesitate to contact me if you have further questions about the Natural Heritage Program. In the future, if you have requests for locations of rare and endangered species, natural communities or registered Critical Areas, contact us directly.

Sincerely,

Francie C. Tolan

Francie C. Tolan
Data Manager
Natural Heritage Program

Enclosures
cc: Critical Areas Program

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MAINE NATURAL HERITAGE PROGRAM
ELEMENTS AND CRITICAL AREAS IN THE ANDROSCOGGIN RIVER BASIN
USGS HYDROLOGIC UNIT MAP, 1974—WATERSHED #01040002

| TOWN................ | SCI.NAME................. | COMMON NAME............. | HP RANK.. | ME.STATUS... | FED.STAT.. | CRIT.AREA. | LAST SEEN |
|---|---|---|---|---|---|---|---|
| ADAMSTOWN TWP | CAREX ECHINATA | LITTLE PRICKLY SEDGE | S1 | T | | | 1975-POST |
| *** | | | | | | | |
| BOWDOINHAM | BIDENS EATONII | EATON'S BEGGAR-TICKS | S1 | T | | | 1988-08-1 |
| BOWDOINHAM | BIDENS HYPERBOREA | ESTUARY BEGGAR-TICKS | S1S2 | T | | 0125 | 1964-09-2 |
| BOWDOINHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | C | 1985-09-1 |
| BOWDOINHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | C | 1985-09-2 |
| BOWDOINHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | 0125 | 1981-SUM |
| BOWDOINHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | 0581 | 1984- |
| BOWDOINHAM | SAGITTARIA RIGIDA | STIFF ARROW-HEAD | SH | E | | | 1916- |
| BOWDOINHAM | SAGITTARIA RIGIDA | STIFF ARROW-HEAD | SH | E | | C | 1921- |
| *** | | | | | | | |
| BOWMANTOWN | DICENTRA CANADENSIS | SQUIRREL-CORN | S1 | T | | | 1988-08-1 |
| BOWMANTOWN | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | | 1988-08-1 |
| BOWMANTOWN | OSMORHIZA CHILENSIS | MOUNTAIN SWEET-CICELY | S1 | T | | | 1988-06-2 |
| BOWMANTOWN | OSMORHIZA CHILENSIS | MOUNTAIN SWEET-CICELY | S1 | T | | | 1988-06-2 |
| *** | | | | | | | |
| BOWMANTOWN TWP | CAREX EBURNEA | EBONY SEDGE | S1 | T | | R0248 | 1975 |
| BOWMANTOWN TWP | CAREX MEDIA | INTERMEDIATE SEDGE | S1 | E | | R0248 | 1987-07-2 |
| BOWMANTOWN TWP | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | R0248 | 1987-07-2 |
| BOWMANTOWN TWP | OSMORHIZA CHILENSIS | MOUNTAIN SWEET-CICELY | S1 | T | | R0248 | 1987-07-2 |
| BOWMANTOWN TWP | SAXIFRAGA PANICULATA | LIVELONG SAXIFRAGE | S1 | T | | R0248 | 1979- |
| BOWMANTOWN TWP | WOODSIA ALPINA | NORTHERN WOODSIA | S1 | T | | R0248 | 1981- |
| BOWMANTOWN TWP | WOODSIA GLABELLA | SMOOTH WOODSIA | S1 | T | | R0248 | 1987-07-2 |
| *** | | | | | | | |
| BUCKFIELD | BROMUS KALMII | WILD CHESS | S1 | E | | | 1971-08-2 |
| BUCKFIELD | MALAXIS BRACHYPODA | WHITE ADDER'S-MOUTH | S1S2 | E | | | 1874-06 |
| *** | | | | | | | |
| CANTON | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1935-09-0 |
| *** | | | | | | | |
| DIXFIELD | CLEMMYS GUTTATA | SPOTTED TURTLE | S3 | T | | | 1965-SUMM |
| DIXFIELD | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1988-MAY |
| *** | | | | | | | |
| FAYETTE | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1878- |
| FAYETTE | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1953-07-1 |
| *** | | | | | | | |
| GREENE | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1923-MAY |

21 MAR 1989 2
MAINE NATURAL HERITAGE PROGRAM
ELEMENTS AND CRITICAL AREAS IN THE ANDROSCOGGIN RIVER BASIN
USGS HYDROLOGIC UNIT MAP, 1974--WATERSHED #01040000

| TOWN............... | SCI.NAME............... | COMMON NAME............. | ME RANK.. | ME.STATUS... | FED.STAT.. | CRIT.AREA. | LAST SEEN |
|---|---|---|---|---|---|---|---|
| *** | | | | | | | |
| GREENWOOD | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1952-05-0 |
| GREENWOOD | HACKELIA DEFLEXA | NORTHERN STICKSEED | S1 | E | | 338 | 1985-05-1 |
| GREENWOOD | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | 338 | 1988-08-1 |
| GREENWOOD | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1985-05-. |
| GREENWOOD | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1985-05-1 |
| GREENWOOD | RHODODENDRON VISCOSUM | CLAMMY AZALEA | S1 | T | | 123 | 1985-06-2 |
| *** | | | | | | | |
| HARTFORD | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1988-09-1 |
| *** | | | | | | | |
| HEBRON | MALAXIS BRACHYPODA | WHITE ADDER'S-MOUTH | S1S2 | E | | | 1895- |
| *** | | | | | | | |
| JAY | MALAXIS BRACHYPODA | WHITE ADDER'S-MOUTH | S1S2 | E | | | 1893-08-1 |
| *** | | | | | | | |
| LEEDS | CEANOTHUS AMERICANUS | NEW JERSEY TEA | S1 | T | | | 1988-07-1 |
| LEEDS | HEMICARPHA MICRANTHA | DWARF BULRUSH | S1 | T | | | 1985-09-3 |
| LEEDS | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1981-09-1 |
| *** | | | | | | | |
| LINCOLN PLT | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | | 1936-08-1 |
| *** | | | | | | | |
| LIVERMORE | MALAXIS BRACHYPODA | WHITE ADDER'S-MOUTH | S1S2 | E | | | 1916-07-0 |
| LIVERMORE | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1922-08-1 |
| LIVERMORE | SELAGINELLA APODA | CREEPING SPIKE-MOSS | S1 | E | | | 1936-08-0 |
| *** | | | | | | | |
| LYNCHTOWN | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | | 1988-08-3 |
| *** | | | | | | | |
| MASON TWP | IMPATIENS PALLIDA | PALE JEWEL-WEED | S2 | T | | 0251 | 1978 |
| *** | | | | | | | |
| NORWAY | CLEMMYS GUTTATA | SPOTTED TURTLE | S3 | T | | | 1883 |
| NORWAY | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1873-05-2 |
| NORWAY | MALAXIS BRACHYPODA | WHITE ADDER'S-MOUTH | S1S2 | E | | | 1923-08-1 |
| *** | | | | | | | |

MAINE NATURAL HERITAGE PROGRAM
ELEMENTS AND CRITICAL AREAS IN THE ANDROSCOGGIN RIVER BASIN
USGS HYDROLOGIC UNIT MAP, 1974—WATERSHED #01040002

| TOWN................ | SCI.NAME................. | COMMON NAME............. | HP RANK.. | ME.STATUS... | FED.STAT.. | CRIT.AREA. | LAST SEEN |
|---|---|---|---|---|---|---|---|
| OXFORD | BROMUS KALMII | WILD CHESS | S1 | E | | | 1914-07- |
| OXFORD | CEANOTHUS AMERICANUS | NEW JERSEY TEA | S1 | T | | 127 | 1984-08-2 |
| *** | | | | | | | |
| PARIS | CRYPTOGRAMMA STELLERI | SLENDER CLIFFBRAKE | S1 | T | | | |
| PARIS | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1982-06-2 |
| *** | | | | | | | |
| PERU | ELEOCHARIS PAUCIFLORA | SPIKE RUSH | S1 | E | | | 1933-08 |
| *** | | | | | | | |
| POLAND | POTAMOGETON VASEYI | VASEY'S PONDWEED | S1 | E | | | 1922- |
| *** | | | | | | | |
| RILEY TWP | HIEROCHLOE ALPINA | ALPINE SWEET-GRASS | S1 | T | | 0114 | 1985-07 |
| *** | | | | | | | |
| STONEHAM | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | N2345 | 1982-08-2 |
| STONEHAM | TRIPHORA TRIANTHOPHORA | NODDING POGONIA | S2 | T | | R0052 | 1982-08 |
| *** | | | | | | | |
| SUMNER | LYCOPODIUM SABINIFOLIUM | GROUND-FIR | S1 | T | | | 1943-08-0 |
| SUMNER | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1986-07-3 |
| *** | | | | | | | |
| TOPSHAM | BIDENS EATONII | EATON'S BEGGAR-TICKS | S1 | T | | 418 | 1981 |
| TOPSHAM | BIDENS HYPERBOREA | ESTUARY BEGGAR-TICKS | S1S2 | T | | 418 | 1981 |
| TOPSHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | C | 1985-09-1 |
| TOPSHAM | CARDAMINE LONGII | LONG'S BITTER CRESS | S2 | T | C2 | 418 | 1986-08-2 |
| *** | | | | | | | |
| TURNER | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1985-09-1 |
| TURNER | UTRICULARIA RESUPINATA | SMALL PURPLE BLADDERWORT | S1 | T | | | 1985-09-1 |
| *** | | | | | | | |
| WAYNE | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | 257 | 1984- |
| WAYNE | LYCOPODIUM SABINIFOLIUM | GROUND-FIR | S1 | T | | | 1986-04-3 |
| *** | | | | | | | |
| WEST PARIS | CRYPTOGRAMMA STELLERI | SLENDER CLIFFBRAKE | S1 | T | | 59 | 1976 |
| WEST PARIS | CYPRIPEDIUM ARIETINUM | RAM'S-HEAD LADY'S-SLIPPER | S1 | T | 3C | | 1945- |
| *** | | | | | | | |

21 MAR 1989 4

MAINE NATURAL HERITAGE PROGRAM

ELEMENTS AND CRITICAL AREAS IN THE ANDROSCOGGIN RIVER BASIN

USGS HYDROLOGIC UNIT MAP, 1974--WATERSHED #01040002

| TOWN................ | SCI.NAME................ | COMMON NAME............. | HP RANK.. | ME.STATUS... | FED.STAT.. | CRIT.AREA. | LAST SEEN |
|---|---|---|---|---|---|---|---|
| WOODSTOCK | PANAX QUINQUEFOLIUS | AMERICAN GINSENG | S2 | T | 3C | | 1985-07-0 |
| WOODSTOCK | RHODODENDRON VISCOSUM | CLAMMY AZALEA | S1 | T | | 123 | 1985-06-0 |

***

August 2, 1988

# EXPLANATION OF LISTS

In order to be included on Maine's Official List, a plant taxon (species, subspecies or variety) must be a vascular plant native to Maine and must be validly published in the scientific literature. Vascular plants include angiosperms (flowering plants), gymnosperms (conifers and relatives), and pteridophytes (ferns and relatives). Lower plant groups -- algae, fungi, lichens, mosses and liverworts -- are not covered.

**Scientific Name** column:

Nomenclature follows Kartesz, J.T. and R. Kartesz (1980. Synonymized checklist of the vascular flora of the United States, Canada and Greenland. Chapel Hill: University of North Carolina Press).

Occurrences column:

**occurrence** = natural, indigenous existence according to Fernald, M.L. (1950. Gray's manual of botany. New York: Van Nostrand Reinhold) and referring either to a population (a group of individuals of the same taxon growing in one place) or to a town (if there is more than one documentation from the town but the best available data do not indicate more than one population);

**recent** = within the past 20 years;

**X** = found within 20 years but believed extirpated (destroyed) because repeated efforts to relocate the occurrence have failed.

**Year Last Documented** column:

**documented** = a correctly identified specimen or photograph.

**Status** column:

**E** = **ENDANGERED**; represented in Maine by one documented, recent occurrence or Federally Endangered (**LE**)*.

**T** = **THREATENED**; represented in Maine by two to four documented, recent occurrences or Federally Threatened (**LT**)*.

**Exceptions** to the above two categories are indicated when recent populations are:

**(a)** = small.
**(b)** = confined to a small geographic area.
**(c)** = clearly and imminently jeopardized.

**SC** = **SPECIAL CONCERN**; represented in maine by five to 10 documented, recent occurrences and could within the foreseeable future become Threatened.

**SC-PE** = **SPECIAL CONCERN - POSSIBLY EXTIRPATED**; has not been documented recently. If found and documented, the taxon is placed in Endangered status upon review of the documentation by the Endangered Plant Technical Advisory Committee and Critical Areas Program staff.

**WL** = **WATCH LIST**; represented in Maine by more than 10 documented recent occurrences but is of concern. Also includes:

- **Subspecific taxa** qualifying for one of the other categories but belonging to a species that in total has more than 10 documented recent occurrences.

- A plant that has been removed from one of the other categories because of reduced threat or increase in population size; further review may or may not suggest delisting.

**/2** = listed in the Federal Register*, but uncertainties regarding taxonomic status or biological vulnerability need to be resolved before the taxon can be listed as Endangered or Threatened at the Federal level.

**/3C** = listed in the Federal Register* although more abundant or widespread than previously believed, and/or subject to any identifiable threat.

* Federal Register of Endangered and Threatened Wildlife and Plants, U.S. Fish and Wildlife Service, Dept. of the Interior, U.S. Government Printing Office, Washington, D.C.

(Lists native plant taxa which have been or are currently being considered for listing as Endangered or Threatened at the Federal level under the Endangered Species Act of 1973).

# Element Ranking Glossary

Element - a rare plant or animal species, exemplary natural community, or "other" special feature (migratory bird concentration site, bat hibernaculum) of the natural landscape

Element Occurrence (=EO) - an area which sustains or otherwise significantly contributes to the survival of a particular element

Element Occurrence Number (=EO Number) - number given to each element occurrence in the state's heritage data base

Element Occurrence Rank (=EO Rank) - each element occurrence is ranked according to the global quality, condition, viability, and defensibility of the occurrence. The codes assigned are: A=excellent, B=good, C=marginal, D=poor.

Element Rank - the priority of an element for conservation. Elements are prioritized first by their global (range-wide) rank, then by their state rank. Both ranks are usually used in combination. See "Priority Sequencing" (below).
Codes used are as follows:

GLOBAL RANKS

- G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor of its biology making it especially vulnerable to extinction.
- G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extinction throughout its range.
- G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the east) or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.
- G4 = Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
- G5 = Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
- GA = Accidental in North America.
- GE = Exotic on North America.
- GH = Occurred historically and may be rediscovered.
- GU = Range-wide status uncertain and possibly in peril; unable to decide rank among 3 or more possible ranks.
- GX = Believed to be extinct throughout range.

STATE RANKS

S1 = Critically imperiled in state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or especially vulnerable to extirpation from the state.

S2 = Imperiled in state because of rarity (6 or 20 occurrences or few remaining individuals or acres) or because of other factors demonstrably making it very vulnerable to extirpation from the state.

S3 = Rare in state (on the order of 20+ occurrences).

S4 = Apparently secure in state.

S5 = Demonstrably secure in state.

SA = Accidental in state.

SE = Exotic in the state.

SH = Of historical occurrence in the state with the expectation that it may be rediscovered.

SU = Status in state uncertain and unable to decide rank among 3 or more possible ranks.

NOTES: (1) Ranking of questionable species -
A "Q" modifier is used with the G-rank to denote taxonomic uncertainty.

(2) Ranking of subspecies or varieties -
A "T" modifier is used with the G-rank to denote the global status of the subspecies or variety. For example, a rare (40 - 100 occurrences world-wide) subspecies of a demonstrably common species which is thought to occur at only a handful of sites in a particular state would receive a rank of G5T3S1 in that state.

(3) Priority Sequencing of Combined G, S, and T Ranks -

Read columns down from left to right.

| | | | | | |
|---|---|---|---|---|---|
| G1 S1 | G2T1 S1 | G3 T1 S1 | GU T2 S1 | G4 T3 S1 | G5 S1 |
| | G2 S1 | GU T1 S1 | GU T2 S2 | G4 T3 S2 | G5 S2 |
| | G2 S2 | G4 T1 S1 | G4 T2 S1 | G4 T3 S3 | G5 S3 |
| | | G5 T1 S1 | G4 T2 S2 | G5 T3 S1 | G5 SU |
| | | G3 T2 S1 | G5 T2 S1 | G5 T3 S2 | G5 S4 |
| | | G3 T2 S2 | G5 T2 S2 | G5 T3 S3 | G5 S5 |
| | | G3 S1 | GU S1 | G4 S1 | |
| | | G3 S2 | GU S2 | G4 S2 | |
| | | G3 S3 | GU S3 | G4 S3 | |
| | | | GU SU | G4 SU | |
| | | | | G4 S4 | |

The state rank cannot be lower than the global rank.

All Q-flagged elements would follow immediately after other elements with the same G-ranks (e.g., all G2Q-ranked elements follow all other G2-ranked elements and precede all G3-ranked elements).

SA, SH, and SX-ranked elements are not included in the priority sequence as they would not appear on a scorecard (there are no permanent, verified EO's for accidental, historic, or extirpated elements).

SE-ranked elements are not included because we are not concerned with the conservation of exotics.

ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

APPENDIX B

HYDROLOGY & HYDRAULICS

ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

APPENDIX B
HYDROLOGY & HYDRAULICS

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## HYDROLOGIC ANALYSIS FOR FLOOD CONTROL ANDROSCOGGIN RIVER, MAINE

1. PURPOSE

This report presents a review and analysis of the hydrology of floods within the Androscoggin River Basin. Included are sections on basin description, climatology, flood history, discharge frequencies, stage-frequency data, analysis of floods and flood control alternatives. This work was performed under the authority set forth in U.S. Senate Resolution, dated 12 November 1987, as amended.

2. BASIN DESCRIPTION

a. General. The Androscoggin River Basin is located principally in southwest Maine with a portion of its headwater area in northeastern New Hampshire. The basin's total drainage area is 3,450 square miles, with 720 square miles (about 20 percent) lying within New Hampshire. Numerous lakes and ponds cover over 143 square miles (approximately 4.1 percent) of the basin's area. A map of the watershed is shown on plate 1.

Hydrologically, the basin can be divided into three distinct areas, each representing about one-third of the watershed. The first is the upper portion of the basin lying above Errol, New Hampshire with a drainage area of 1,045 square miles. There are 6 major lakes (collectively called the Rangeley Lakes) in this section of the basin, with a total usable storage capacity of 660,000 acre-feet. All are operated by the Union Water Power Company (UWPC) for power and recreation. These lakes, with their large usable storage capacity, have a modifying effect on floodflows, and as a result, this area historically has not been a major contributor to downstream flood peaks.

The second or middle section of the watershed lies between Errol, New Hampshire and the mouth of the Webb River, with a net drainage area of approximately 1,300 square miles. This area is characterized by mountainous terrain and relatively short tributaries with steep slopes. It is this section of the watershed which tends to contribute most to flood peaks on the main stem of the Androscoggin River.

The lower third of the watershed drains a net area of 1,105 square miles and has drainage more typical of the Maine

Coastal Region. This area, has long, flat tributaries, and many small lakes and ponds, which tend to retard and modify the tributaries' floodflows. Because of the long travel times along the main stem Androscoggin River and the hydrologic characteristics of these lower basin tributaries, historic floodflows from the lower basin have generally been synchronous with main stem peaks.

b. Androscoggin River. The Androscoggin River originates at Errol Dam, the outlet of Umbagog Lake in Errol, New Hampshire. The river flows in a southerly direction, turning east at Gorham, and south again at Livermore Falls to its outlet in Merrymeeting Bay. Between Umbagog Lake and tidewater at Brunswick, the Androscoggin River drops 1,245 feet in 161 miles, for an average slope of 7.7 feet per mile. Of this total fall, however, about 32 percent occurs at two locations. The first, a 240-foot drop in 2.5 miles near Berlin, New Hampshire, and the second a 180-foot drop in 1.6 miles near Rumford. Pertinent data for the Androscoggin River and its tributaries is shown in table 1. A profile of the Androscoggin River is shown on plates 2A through 2C.

c. Headwater Tributaries. The headwaters, as defined in this report, is that area above Errol. The major headwater tributaries include watersheds of the Cupsuptic, Kennebago, and Magalloway Rivers. The area extends north about 50 to 55 miles above the outlet of Umbagog Lake at Errol Dam, and has a width of about 35 miles and drainage area of about 1,045 square miles.

(1) Cupsuptic and Kennebago Rivers. These two headwater tributaries originate in Cupsuptic and Rock Ponds, respectively. The Cupsuptic River, from its source at an elevation of 2,485 feet NGVD, flows south about 20 miles to Cupsuptic Lake. The Kennebago River also follows a general southerly course from its headwater pond, at an elevation of 2,167 feet NGVD, to its mouth at Mooselookmeguntic Lake, a distance of about 29 miles. Cupsuptic Lake is the northern portion of the large Mooselookmeguntic Lake which has a normal water surface elevation of about 1,467 feet NGVD. The flow from this lake system discharges directly to the Upper and Lower Richardson Lakes, which have a normal water surface elevation of 1,448 feet NGVD. Discharges from Middle Dam at the Lower Richardson Lake form the Rapid River, which flows about 6 miles to Umbagog Lake. Normal pool elevation at Umbagog Lake is 1,245 feet NGVD.

(2) Magalloway River. The Magalloway River has its source in the mountains along the Maine/New Hampshire border and flows through Aziscohos Lake and then follows a meandering course in a southerly direction for about 47 miles to its

TABLE 1

ANDROSCOGGIN RIVER AND TRIBUTARIES

| River or Tributary | Drainage Area (sq mi) | Length (miles) | Fall (feet) |
|---|---|---|---|
| Cupsuptic River at Mouth | 62.5 | 20 | 1,001 |
| Kennebago River at Mouth | 138 | 29 | 700 |
| Magalloway River at Umbagog Lake | 439 | 47 | 505 |
| Diamond River at Mouth | 154 | 17 | 85 |
| Rapid River at Umbagog Lake | 520 | 7 | 206 |
| Androscoggin River at Errol, NH, USGS Gage | 1,045 | - | - |
| Androscoggin River near Gorham, NH, USGS Gage | 1,363 | - | - |
| Peabody River at Mouth | 47 | 12 | 2,240 |
| Moose River at Mouth | 24 | 12 | 1,880 |
| Wild River at Mouth | 69 | 15 | 2,080 |
| Sunday River at Mouth | 51 | 14 | 1,620 |
| Bear River at Mouth | 43 | 13 | 860 |
| Ellis River at Mouth | 163 | 20 | 200 |
| Androscoggin River at Rumford, ME, USGS Gage | 2,067 | - | - |
| Swift River at Mouth | 125 | 25 | 1,795 |
| Webb River at Mouth | 132 | 15 | 285 |
| Dead River at Mouth | 89 | 23 | 650 |
| Nezinscot River at Mouth | 181 | 31 | 593 |
| Little Androscoggin River at Mouth | 353 | 46 | 580 |
| Androscoggin River near Auburn, ME, USGS Gage | 3,257 | - | - |
| Androscoggin River at Head of Tidewater, Brunswick, ME | 3,450 | 161 | 1,245 |

mouth at Umbagog Lake. It drains an area of 439 square miles and has a fall of approximately 500 feet. The principal tributary of the Magalloway River is the Diamond River consisting of the Dead Diamond and Swift Diamond Rivers. The Diamond Rivers drain steep mountainous slopes with headwater elevations in excess of 3,000 feet NGVD. From the confluence of the two Diamond River tributaries, the river then flows in a southeasterly direction for about 1.7 miles, with a slope of approximately 5 feet per mile, to its junction with the Magalloway River, about 10.5 miles above its mouth at Umbagog Lake.

(3) Rapid River. Rapid River has its source at the outlet of the Richardson Lakes at Middle Dam and flows on a general northwesterly course for about 7 miles to Umbagog Lake. It drains an area of about 520 square miles which includes the Kennebago, Rangeley, Mooselookmeguntic and Richardson Lakes.

d. Downstream Tributaries. Principal tributaries of the main stem Androscoggin River below Umbagog Lake are listed below in downstream order:

(1) Moose River. The Moose River has its source in the town of Bowman, New Hampshire and flows in a general northeast direction to its confluence with the Androscoggin River in the town of Gorham, New Hampshire. It has a drainage area of about 24 square miles and extends from the peaks of the Presidential Range for about 12 miles to its mouth with a total fall of about 1,880 feet. Topography of the basin is mountainous with steep slopes producing rapid runoff.

(2) Peabody River. The Peabody River rises in the northwest portion of the town of Pinkham Notch, New Hampshire and flows in a general northwesterly direction to its confluence with the Androscoggin River in the southeast corner of the town of Gorham. It drains an area of about 47 square miles and extends from the summit of Mount Washington for about 12 miles to its mouth and has a total fall of about 2,240 feet. The topography of this basin is similar to that of Moose River Basin.

(3) Wild River. The Wild River has its source at North Ketchum Pond in Beans Purchase, New Hampshire. The river follows a generally northeasterly course entering the Androscoggin River in the northwest corner of Gilead, Maine. Like the Moose and Peabody Rivers, it drains the eastern slopes of the White Mountains. Its drainage area of 69 square miles extends from the summit of Wildcat Mountain,

adjacent to Mount Washington, for about 15 miles and has a total fall of about 2,080 feet. The topography at this basin is mountainous and similar to the Moose and Peabody River basins.

(4) Sunday River. The Sunday River has its source in the vicinity of Goose Eye Mountain, draining an area north of the Androscoggin River in Riley, Maine. It flows in a general southeasterly direction for about 14 miles to its confluence with the Androscoggin River in the town of North Bethel, Maine. It drains an area of approximately 51 square miles and has a fall of about 1,620 feet.

(5) Bear River. The Bear River has its source just south of the town of Grafton Notch, Maine and flows in a southeasterly course for about 13 miles entering the Androscoggin River at Newry, Maine. Drainage area is about 43 square miles and its fall about 860 feet.

(6) Ellis River. The Ellis River rises in Ellis Pond in the town of Roxbury, Maine and flows generally south about 20 miles to its confluence with the Androscoggin River near Hanover, Maine. Topography of the basin above Andover, Maine is mountainous with steep slopes and very little effective channel storage. Below this point, there is a broad flat plain which extends about seven miles below North Rumford. The Ellis River has a drainage area of 163 square miles and a fall of about 200 feet. Unlike the previously mentioned tributaries draining steep mountainous slopes, the Ellis River is more hydrologically sluggish with a considerable amount of natural storage.

(7) Swift River. This river rises in Swift River Pond about 6 miles northeast of the town of Houghton, Maine and flows southerly about 25 miles to its confluence with the Androscoggin River at Mexico and Rumford. It drains an area of 125 square miles and has a fall of approximately 1,800 feet.

(8) Webb River. The Webb River rises in Lake Webb in the town of Weld, Maine at an elevation of 678 feet NGVD. The river follows a meandering course in a southerly direction for about 15 miles to its mouth at the Androscoggin River at Dixfield, Maine. Drainage area is 132 square miles and its fall about 285 feet.

(9) Dead River. The source of this tributary is in Kimball Pond on the town line between Vienna and New Sharon, Maine. Flow from the pond is first confined to a small stream that runs south about 3.5 miles at an average slope of

160 feet per mile. It then continues south about 17.5 miles through a series of 9 lakes and ponds connected by short streams, dropping approximately 75 feet within this reach of lakes. The Dead River originates at the outlet of Androscoggin Lake, the most southerly lake in the series, and flows in a general northwesterly direction for about 7 miles, at a very gentle slope, to its confluence with the Androscoggin River 5 miles north of West Leeds. It drains an area of 89 square miles and is hydrologically sluggish with extensive storage within the watershed, more typical of the Maine Coastal Region.

(10) Nezinscot River. The East and West Branches of the Nezinscot River rise in the southern slopes of a hilly region in the southern part of Peru and the northwest corner of Woodstock, Maine. The two branches flow in a general southeasterly direction about 16 miles, uniting at a point one mile below the village center of Buckfield to form the Nezinscot River. Below Buckfield, the Nezinscot River follows an easterly course for 14 miles to its mouth at the Androscoggin River at Keens Mills, about 4.5 miles northeast of Turner, Maine. It has a drainage area of 181 square miles and a fall of about 590 feet from the confluence of the two branches to the Androscoggin.

(11) Little Androscoggin River. The Little Androscoggin River rises in Bryant Pond in Woodstock, Maine at an elevation of about 700 feet above mean sea level. The river flows south for a short distance and then generally east for the remainder of its 46-mile length where it joins the Androscoggin River at Auburn, Maine. It drains an area of 353 square miles and has a fall of 580 feet.

e. Dams and Reservoirs. There is a total of 725,300 acre-feet of usable reservoir storage in the Androscoggin River Basin, with 660,500 acre-feet (90 percent) located above Errol Dam. Table 2 lists storage locations and pertinent data for each storage site. Union Water Power Company operates and maintains the storage in the Rangeley lakes system, made up of 6 lakes and dams located in the upper basin above Errol Dam. The system of lakes is operated to maintain a flow of not less than 1,550 cfs through releases at Errol Dam (approximately 1 CSM) as measured at Berlin, New Hampshire, per agreement with Union Water Power Company and three other power companies on the Androscoggin River, dating back to 31 March 1909 (reference f). This flow is maintained primarily for downstream power uses and industrial developments along the Androscoggin River. During the summer and fall, releases from the lakes tend to empty the system, allowing the lakes to be fully drawn down for the spring runoff

TABLE 2

AVAILABLE STORAGE
ANDROSCOGGIN RIVER BASIN

| Reservoir | Drainage Area (sq mi) Net | Drainage Area (sq mi) Gross | Draw-Down (ft) | Useable Storage Capacity Cubic Feet (million) | Useable Storage Capacity Acre-Feet | Inches of Runoff*** |
|---|---|---|---|---|---|---|
| **Upper Androscoggin Basin*** | | | | | | |
| Kennebago Lake | 101 | 101 | 4 | 721 | 16,600 | 3.1 |
| Rangeley Lake | 99 | 99 | 4 | 1,340 | 30,800 | 5.8 |
| Mooselookmeguntic Lake | 182 | 382 | 12.2 | 8,360 | 191,900 | 19.8 |
| Upper and Lower Richardson Lakes | 90 | 472 | 17.5 | 5,690 | 130,600 | 27.2 |
| Aziscohos Lake | 214 | 214 | 45 | 9,510 | 218,300 | 19.1 |
| Umbagog Lake | 359 | 1,045 | 8 | 3,150 | 72,300 | 3.8 |
| Total Above Berlin, NH | | | | 28,771 | 660,500** | |
| **Lower Androscoggin Basin** | | | | | | |
| Gulf Island Pond | 2,862 | | 10 | 1,100 | 25,300 | 0.16 |
| **Little Androscoggin River** | | | | | | |
| Pennesseewasee Lake | 23 | | 5 | 192 | - | |
| Thompson Lake | 44 | | 5 | 950 | | |
| Total Above Mechanic Falls, ME | | | | 1,142 | 26,200 | |
| **Other Tributaries** | | | | | | |
| Lake Auburn | 17 | | 6 | 580 | 13,300 | |
| Basin Total | | | | 31,593 | 725,300 | |

* Source - Union Water Power Company

** Equivalent to nearly 12 inches of runoff from 1,045 square miles of contributing drainage area above Errol Dam.

*** Inches of runoff from net drainage areas and subsequent refill season. The amount of storage in the Rangeley Lakes is equivalent to 12 inches of runoff from the 1,045 square miles of contributing drainage area above Errol Dam. This operation helps to greatly modify the effects of floodflows from the upper portion of the basin.

Currently there are 24 Federal Energy Regulatory Commission (FERC) licensed hydroelectric sites in the Androscoggin River Basin, 22 of which are located downstream of Errol Dam (reference c). Table 3 lists these sites and pertinent information. Due to the limited storage capacity, downstream power dams are run-of-river except the Gulf Island project, which has storage capacity primarily for daily or weekly "load fitting" operations.

3. CLIMATOLOGY

The Androscoggin River Basin is characterized by cool summers and cold snowy winters. Prevailing westerlies and cyclonic disturbances from the west and southwest bring frequent but short periods of heavy precipitation to the basin. Most of the basin lies inland and escapes the brunt of coastal hurricanes and accompanying intense rainfall. The basin's average annual temperature is 43 $^{o}$F. The range of mean monthly temperatures is wide, with 64 to 70 $^{o}$F in July and August to 15 to 20 $^{o}$F in January and February. Temperature extremes range from occasional highs over 100 $^{o}$F to lows less than -30 $^{o}$F. Table 4 lists monthly and annual temperatures at Errol and Berlin, New Hampshire and Rumford and Lewiston, Maine. Average annual precipitation is 40 inches, uniformly distributed throughout the year. Average monthly and annual precipitation over the basin is listed in table 5. Most of the winter precipitation is in the form of snow. Annual snowfall varies from 80 inches near the coast to 170 inches in the headwaters of the basin. Water content of the snow cover in early spring is about 6 to 8 inches; 10 inches is common in the higher basin elevations. Table 6 lists mean monthly and annual snowfall at 4 locations in the basin.

4. STREAMFLOW

a. Runoff. Average annual streamflow is approximately 1.8 cfs per square mile of watershed area. This is equivalent to 25 inches of runoff, or about 60 percent of the average annual precipitation. Over 40 percent of the runoff occurs during March, April, and May, with the rest uniformly distributed throughout the year.

b. Streamflow Records. The U.S. Geological Survey (USGS) has operated a system of streamflow gaging stations at

TABLE 3

PERTINENT DATA
FERC LICENSED, HYDROPOWER SITES

| FERC License | Plant Name | Owner | River Mile | Location |
|---|---|---|---|---|
| 2284 ME | Brunswick | Central Maine Power Co. | 8.0 | Brunswick, ME |
| 2284 ME | Topsham | Central Maine Power Co. | 8.0 | Topsham, ME |
| 4784 ME | Pejepscot | Pejepscot Paper Co. | 12.7 | Topsham, ME |
| - | Lisbon Falls | Worumbo Div. - J. P. Stevens Co. | 16.0 | Lisbon Falls, ME |
| - | Norway | Central Maine Power Co. | - | Norway, ME |
| 2302 ME | Lewiston Falls | Union Water Power Co. | 30.8 | Lewiston, ME |
| 2302 ME | Lewiston | Pepperell Manfacturing Co. | 30.8 | Lewiston, ME |
| 2302 ME | Lewiston | W. S. Libby Co. | 30.8 | Lewiston, ME |
| 2302 ME | Lewiston | P. Hall Enterprises, Inc. | 30.8 | Lewiston, ME |
| 2302 ME | Lewiston | Bates Manufacturing Co. | 30.8 | Lewiston, ME |
| 2302 ME | Hill Div. | Bates Manufacturing Co. | 30.8 | Lewiston, ME |
| 2302 ME | Androscoggin | Bates Manufacturing Co. | 30.8 | Lewiston, ME |
| 2302 ME | Lewiston | Lewiston Public Works | 30.8 | Lewiston, ME |
| 2283 ME | Deer Rips | Central Maine Power Co. | 33.6 | Lewiston, ME |
| 2283 ME | Androscoggin #3 | Central Maine Power Co. | 33.6 | Lewiston, ME |
| 2283 ME | Gulf Island | Central Maine Power Co. | 34.8 | Lewiston, ME |
| 2375 ME | Livermore Mill | International Paper Co. | 60.8 | Livermore Falls, ME |
| 2375 ME | Otis | International Paper Co. | 61.8 | Chisholm, ME |
| 2375 ME | Jay | International Paper Co. | 63.8 | Jay Bridge, ME |
| 2375 ME | Riley | International Paper Co. | 66.6 | Riley, ME |
| 2333 ME | Rumford Lower | Rumford Falls Power Co. | 87.2 | Rumford, ME |
| 2333 ME | Rumford Upper | Rumford Falls Power Co. | 87.4 | Rumford, ME |
| 2300 NH | Shelburne | Brown Company | 127.6 | Shelburne, NH |
| 2288 NH | Gorham | Public Service Co. of NH | 130.3 | Gorham, NH |
| 2288 NH | Gorham | Brown Company | 132.6 | Gorham, NH |
| 2327 NH | Cascade | Brown Company | 135.6 | Gorham, NH |
| 2326 NH | Cross Power | Brown Company | 136.1 | Berlin, NH |
| 2287 NH | J. Brodie Smith | Public Service Co. of NH | 136.7 | Berlin, NH |
| 2423 NH | Riverside | Brown Company | 137.8 | Berlin, NH |
| 2422 NH | Sawmill | Brown Company | 138.2 | Berlin, NH |
| 2861 NH | Pontook | Union Water Power Co. | 152.1 | Pontook, NH |
| 3133 NH | Errol | Union Water Power Co. | 170.0 | Errol, NH |
| - | Kennebago | Rangeley Power Co. | 217.0 | Kennebago, ME |

TABLE 4

MONTHLY TEMPERATURES
(Degrees, Fahrenheit)

Lewiston, Maine
Elevation 182 Ft NGVD
100 Years of Record

| Month | Mean | Max | Min |
|---|---|---|---|
| January | 19.5 | 64 | -28 |
| February | 20.6 | 62 | -28 |
| March | 30.8 | 82 | -18 |
| April | 42.5 | 87 | 10 |
| May | 54.4 | 101 | 27 |
| June | 64.1 | 99 | 34 |
| July | 69.8 | 102 | 44 |
| August | 67.8 | 98 | 38 |
| September | 59.9 | 97 | 28 |
| October | 49.3 | 90 | 18 |
| November | 36.9 | 74 | 2 |
| December | 24.3 | 65 | -27 |
| ANNUAL | 44.9 | 102 | -28 |

Rumford, Maine
Elevation 674 Ft NGVD
82 Years of Record

| Month | Mean | Max | Min |
|---|---|---|---|
| January | 17.2 | 64 | -34 |
| February | 18.6 | 58 | -34 |
| March | 29.1 | 79 | -23 |
| April | 41.1 | 89 | - 1 |
| May | 53.2 | 97 | 24 |
| June | 61.8 | 98 | 26 |
| July | 67.9 | 101 | 38 |
| August | 65.5 | 100 | 36 |
| September | 57.6 | 95 | 22 |
| October | 47.0 | 88 | 15 |
| November | 34.7 | 76 | - 5 |
| December | 21.8 | 63 | -29 |
| ANNUAL | 42.9 | 101 | -34 |

Berlin, New Hampshire
Elevation, 1,110 Ft NGVD
72 Years of Record

| Month | Mean | Max | Min |
|---|---|---|---|
| January | 14.7 | 67 | -41 |
| February | 14.6 | 63 | -39 |
| March | 30.6 | 80 | -29 |
| April | 45.7 | 88 | - 9 |
| May | 53.2 | 94 | 3 |
| June | 63.0 | 98 | 24 |
| July | 68.0 | 100 | 34 |
| August | 62.9 | 97 | 20 |
| September | 56.5 | 94 | 8 |
| October | 44.0 | 88 | 8 |
| November | 33.7 | 77 | -13 |
| December | 26.1 | 66 | -44 |
| ANNUAL | 42.8 | 100 | -44 |

Errol, New Hampshire
Elevation 1,280 Ft NGVD
9 Years - 1932 thru 1941

| Month | Mean | Max | Min |
|---|---|---|---|
| January | 16.9 | 53 | -30 |
| February | 18.6 | 49 | -24 |
| March | 27.2 | 64 | -20 |
| April | 40.1 | 78 | 5 |
| May | 51.9 | 88 | 26 |
| June | 61.7 | 92 | 32 |
| July | 66.4 | 92 | 44 |
| August | 64.0 | 90 | 36 |
| September | 56.0 | 87 | 24 |
| October | 44.9 | 78 | 18 |
| November | 34.3 | 68 | - 6 |
| December | 21.6 | 60 | -32 |
| ANNUAL | 42.0 | 92 | -32 |

TABLE 5

MONTHLY PRECIPITATION RECORDS

| Month | Lewiston, Maine Elevation 182 Ft NGVD 110 Years of Record Mean (In Inches) | Rumford, Maine Elevation 674 Ft NGVD 91 Years of Record Mean (In Inches) | Errol, New Hampshire Elevation 1,280 Ft NGVD 100 Years of Record Mean (In Inches) | Berlin, New Hampshire Elevation 1,110 Ft NGVD 90 Years of Record Mean (In Inches) |
|---|---|---|---|---|
| January | 3.86 | 2.95 | 2.70 | 2.73 |
| February | 3.63 | 2.59 | 2.53 | 2.30 |
| March | 4.17 | 3.38 | 2.89 | 2.81 |
| April | 3.66 | 3.35 | 2.92 | 2.90 |
| May | 3.38 | 3.42 | 3.28 | 3.16 |
| June | 3.41 | 3.59 | 3.72 | 3.87 |
| July | 3.49 | 3.74 | 3.37 | 3.48 |
| August | 3.32 | 3.42 | 3.70 | 3.33 |
| September | 3.46 | 3.51 | 3.00 | 3.37 |
| October | 3.63 | 3.50 | 3.09 | 3.24 |
| November | 4.26 | 3.93 | 3.61 | 3.62 |
| December | 4.16 | 3.36 | 3.23 | 3.04 |
| ANNUAL | 44.24 | 40.90 | 38.15 | 37.77 |

TABLE 6

MEAN MONTHLY SNOWFALL
(Depth in Inches)

Lewiston, Maine
Elevation 182 Ft NGVD
96 Years of Record

| Month | Snowfall |
|---|---|
| January | 21.0 |
| February | 20.8 |
| March | 13.3 |
| April | 5.0 |
| May | 0.1 |
| October | 0.3 |
| November | 5.8 |
| December | 15.7 |
| ANNUAL | 82.1 |

Rumford, Maine
Elevation 674 Ft NGVD
82 Years of Record

| MONTH | Snowfall |
|---|---|
| January | 22.0 |
| February | 20.6 |
| March | 15.9 |
| April | 6.6 |
| May | 0.4 |
| October | 0.6 |
| November | 7.5 |
| December | 18.4 |
| ANNUAL | 91.9 |

Berlin, New Hampshire
Elevation 1,110 Ft NGVD
61 Years of Record

| Month | Snowfall |
|---|---|
| January | 22.6 |
| February | 21.9 |
| March | 20.6 |
| April | 7.0 |
| May | 0.4 |
| October | 1.2 |
| November | 9.9 |
| December | 18.0 |
| ANNUAL | 101.6 |

Errol, New Hampshire
Elevation 1,288 Ft NGVD
39 Years of Record

| Month | Snowfall |
|---|---|
| January | 23.5 |
| February | 17.9 |
| March | 16.4 |
| April | 4.2 |
| May | 0.7 |
| October | 0.3 |
| November | 3.1 |
| December | 20.9 |
| ANNUAL | 92.9 |

various sites and for various periods of time in the basin since the early 1900's, with nine stations presently in operation. Early records were also maintained by local dam operators for the power companies; the Rumford gage was maintained by the Rumford Falls Power Company from 1892 to 1979. Table 7 lists the gages used in the analysis of the basin floods. It is noted that some gaging stations have been discontinued, and many of the tributaries have never been gaged. Supplemental flow and reservoir storage data for recent floods was furnished by the Union Water Power Company.

5. FLOODS OF RECORD

a. Flood History. The history of floods in the Androscoggin River Basin goes back over 200 years with records indicating floods in 1785, 1814, 1820, 1826, 1827, 1846, and 1869. However, information on the relative magnitude of flood events is generally not available prior to 1892, when the Rumford Falls Power Company began recording riverflows at Upper Falls, Rumford, Maine. High flows in the basin occur almost annually, usually in the spring months of March, April, or May, and vary in magnitude depending on water content of the melting snow cover, the occurrence of coincidental heavy spring rainfall, temperature, and the extent of frost. The three greatest known floods: March 1936, March 1953, and March/April 1987 were a result of a combination of these factors. Discharges and stages of spring floods can also be increased due to the formation of ice jams. This occurred during the March 1936 flood at Auburn. Heavy rainfall at other times of the year can also produce flooding as evidenced by the floods of November 1927 and 1950, and June 1942 and 1947.

b. Recent Floods. The March 1936 flood was the greatest flood of record in the lower reaches of the Androscoggin River Basin. This flood was caused by unseasonably warm temperatures and heavy rain on top of a snow cover having approximately 10 inches of water equivalent. Flooding at several locations was further aggravated by severe ice jams. Two distinct storms occurred in March. During the first storm, 11 to 13 March, 5.8 inches of rainfall was recorded in Rumford, Maine and 7.8 inches at Pinkham Notch, New Hampshire. During the second storm, 16 to 21 March, 5.8 inches was recorded at Rumford and 13.0 inches at Pinkham Notch. The second storm produced the highest recorded peak flow at Rumford (74,000 cfs) and the largest flood losses experienced in the basin.

The March/April 1987 flood, the second largest basin-wide event, was caused by a pair of rainstorms, augmented by snowmelt in higher elevations of the basin. The first storm,

TABLE 7

STREAMFLOW RECORDS
ANDROSCOGGIN RIVER BASIN

| Location of Gaging Station | Drainage Area (sq mi) | Period of Record | Discharge (CFS) Mean | Maximum | Minimum |
|---|---|---|---|---|---|
| Diamond River near Wentworth Location, NH | 153 | 1941- | 349 | 8,630 06/16/43 | 6.8 |
| Androscoggin River at Errol, NH | 1,045 | 1905- | 1,905 | 16,500 05/22/69 | Leakage |
| Androscoggin River at Berlin, NH | 1,350 | 1913-1928 | 2,313 | 20,000 06/18/17 | 960* |
| Androscoggin River at Gorham, NH | 1,363 | 1928- | 2,467 | 20,000* 04/30/23 | 456 |
| Wild River at Gilead, ME | 69.5 | 1964- | 183 | 19,000 04/05/84 | 7.6 |
| Ellis River at South Andover, ME | 131 | 1963-1982 | 250 | 5,630 12/29/69 | 12 |
| Androscoggin River at Rumford, ME | 2,067 | 1892- | 3,724 | 74,000 03/20/36 | 625* |
| Swift River near Roxbury, ME | 95.8 | 1929- | 199 | 16,800 10/24/59 | 3.8 |
| Nezinscot River at Turner Center, ME | 171 | 1941- | 306 | 13,900 03/27/53 | 5.6 |
| Little Androscoggin River near South Paris, ME | 76.2 | 1913-1924; 1931- | 139 | 9,300 04/11/87 | 1 |
| Little Androscoggin River near Auburn, ME | 328 | 1940-1982 | 569 | 16,500 03/28/53 | 14* |
| Androscoggin River near Auburn, ME | 3,257 | 1928- | 6,151 | 135,000 03/20/36 | 340* |

*Daily Discharges

occurring from 31 March to 1 April, was a fast moving storm system with heavy rainfall, strong southerly winds, and temperatures in the fifties and sixties. Two to 4 inches of rain fell over the Androscoggin on "ripe" snowpacks with 3 to 5 inches of water equivalent. Major flooding was experienced along the entire length of the main river, from Berlin to Brunswick, and along several tributaries. The recorded peak flow at Rumford was 57,000 cfs. The second storm, 4 to 8 April, was an intense, slow moving storm, delivering most of its punch to the southern and central parts of New England. About 1 to 2 inches of rain fell over the Androscoggin.

The March 1953 flood was the third largest basin-wide flood. Precipitation occurred during most of the month, culminating with approximately 5 inches falling over the basin from 24-27 March. Rainfall amounting to over 9 inches was recorded at Pinkham Notch in the White Mountain Region. Flooding throughout the watershed was comparable to the recent April 1987 event. The recorded peak flow at Rumford was 56,700 cfs.

Table 8 lists the three largest basin-wide floods of record at USGS gaged locations within the basin.

6. DISCHARGE FREQUENCIES

a. General. Peak discharge-frequencies were developed at pertinent USGS gaging stations within the watershed. In general, statistical analysis of the recorded peak annual flows (including March/April 1987, where available) were performed using a Log Pearson Type III distribution in accordance with guidelines as presented in WRC Bulletin 17B (reference d).

b. Androscoggin River. Peak discharge-frequencies were computed for the main stem Androscoggin gages at Gorham, Rumford, and Auburn. Gaged data at Errol was not analyzed due to the high degree of regulation upstream of Errol. Computed main stem curves, with resulting statistics shown on the individual curves, are shown on plate 3. Based on previous Corps of Engineer studies, a regional skew coefficient of 1.0 was adopted.

Since major damage centers within the Androscoggin are located downstream of Rumford, several steps were taken to develop discharge frequencies at pertinent locations between the Rumford and Auburn gages. The first, just below the confluence with the Swift River (DA = 2,195 square miles), was computed by transferring the adopted Rumford curve by straight drainage area ratio. This ratio was considered reasonable based on the ratio of historic flood peaks

TABLE 8

MAJOR FLOODFLOWS -
ANDROSCOGGIN RIVER BASIN

| Location USGS Gaging Station | Drainage Area (sq.mi.) | Period of Record | Peak Discharges (CFS) | | |
|---|---|---|---|---|---|
| | | | March 1936 | March 1953 | March/ April 1987 |
| Androscoggin River at Gorham, NH | 1,363 | 1928- | 19,900 | 17,900 | 16,020 |
| Androscoggin River at Rumford, ME | 2,067 | 1892- | 74,000 | 56,700 | 57,000 |
| Androscoggin River at Auburn, ME | 3,257 | 1928- | 135,000* | 95,800 | 102,000 |
| Swift River near Roxbury, ME | 95.8 | 1929- | 10,500 | 10,200 | 15,860 |
| Nezinscot River at Turner Center, ME | 171 | 1941- | - | 13,900 | 9,990 |

* Effects of Ice Jam, Estimated Peak about 118,000 cfs

(1936, 1953, and 1987) at the two locations. Further downstream, below the confluence with the Webb River (DA = 2,660 square miles), a second curve was calculated by transferring the adopted Rumford curve by drainage area ratio to the 0.7 exponential power, again in general agreement with observed and calculated historic flood peaks at the two locations. The computed curve at Auburn was used to develop a discharge frequency curve at one upstream location, above the confluence with the Little Androscoggin River (DA =2,910 square miles). After reviewing historic flood peaks, a straight drainage area ratio was considered reasonable and adopted to transfer computed discharges.

c. Tributaries. Peak discharge-frequencies were also developed for the following gaged tributaries within the Androscoggin Basin: the Wild, Ellis, Swift, Nezinscot, and Little Androscoggin Rivers. Computed curves, together with resulting statistics for each curve, are shown on plate 4.

On the Little Androscoggin River damage areas were located downstream of the Auburn gage. Therefore, discharge frequencies were developed at these locations by transferring the computed curve at the gage by drainage area ratio to the 0.7 exponential power, with the resulting curve shown on plate 4.

7. STAGE FREQUENCIES

As part of the New England New York Inter-Agency Committee (NENYIAC) Studies and a Survey Report for the river basin (references a and b), the Corps of Engineers conducted extensive damage surveys throughout the watershed. As a result of these investigations, areas having the highest damage potential were found to be along the Androscoggin River, generally south of Rumford and along the Little Androscoggin River from the Auburn gage site to the mouth. Hydraulic analysis during these past studies developed discharge rating curves at many hydraulic structures along both rivers. The rivers were then separated into damage zones with one or more of these rating curves representing conditions within the reach. These rating curves represent free flow conditions and are not applicable at times of ice blockage or excessive debris buildup, both of which could affect local river stages. Also, these Corps developed rating curves were compared with flood profiles presented in the more recently prepared FEMA flood insurance studies (reference G) at various communities within the basin. There is relatively close agreement between the rating curves and computed flood profiles in the flood insurance study reports. Therefore, the previously developed rating curves were utilized, along with adopted discharge-frequency curves, to develop stage-frequency data for both the Androscoggin and Little Androscoggin Rivers. This data is presented in table 9. Also shown in table 9 are USGS obtained 1936 and 1987 high watermark information reference e), where available. In addition, pertinent stage-frequency curves are shown on plates 5A through 5C.

As can be seen from the various hydraulic analysis and surveyed high watermark information, river levels during major flood events are between 15 and 25 feet above normal along the Androscoggin River between Rumford and Auburn.

8. ANALYSIS OF FLOODS

a. General. For this study, the major floods of record (March 1936, March 1953, and March/April 1987) were analyzed to determine the hydrologic development of floods and tributary contributions to flood peaks on the main stem. This analysis is essential to determine flood potential of the basin and recognize the tributaries or subwatershed areas that offer the most potential for reduction of main stem flood levels. For purposes of the hydrologic analysis, the basin was divided into two sections; the large upstream storage areas above Errol, and the unregulated river basin below Errol. The basin below Errol was further divided into reaches with key index stations located at USGS gaging stations at Gorham, Rumford, and Auburn. In addition, other key locations were identified at mouths of larger tributaries and other points along the main stem. Streamflow and storage data from the USGS and Union Water Power Company were used for this analysis. Ungaged area hydrographs were developed using characteristically similar gaged watersheds and prorating the observed hydrographs by drainage area ratio. Flood hydrographs along the Androscoggin River were routed downstream with allowance made for travel time, characteristics of the river reach, amount of intervening flow, and relative timing of peak flows.

The 1936 and 1953 floods were previously studied using the methodology as detailed below. Results are shown graphically on plates 6 and 7. The 1987 event was analyzed during this study and is shown on plate 8.

b. Effects of Upstream Storage. The Androscoggin River Basin upstream of Errol Dam has approximately 660,500 acre-feet of storage (equivalent to 12 inches of runoff from the 1,045-square mile contributing drainage area) in the Rangeley Lakes system. Flood runoff from this area is greatly modified by the large amounts of storage in the lakes. Average daily outflows from Rangeley, Mooselookmeguntic, Upper and

TABLE 9

ELEVATION-FREQUENCY DATA
ANDROSCOGGIN RIVER

| River Mile | Zone | Location | Elevations (Feet NGVD) 2-Year | 10-Year | 50-Year | 100-Year | 500-Year | 1936 | 1987 |
|---|---|---|---|---|---|---|---|---|---|
| 7.9 | 1 - Mouth to Pejepscot Paper Co. dam, RM 12.5 | T/W Central Maine Power Co. dam | 10.3 | 14.2 | 18.8 | 21.4 | 28.5 | 23.4 | - |
| 8.0 | 1 - As above | H/W Central Maine Power Co. dam | 26.2 | 29.6 | 33.1 | 34.8 | 39.3 | 36.1 | - |
| 8.6 | 1 - As above | Central Maine Railroad bridge | 51.1 | 55.1 | 59.4 | 61.7 | 67.8 | 63.5 | - |
| 13.6 | 2 - Pejepscot Paper Co. dam, RM 12.5 to mouth Sabattus River, RM 17.7 | T/W Pejepscot Paper Co. dam | 56.8 | 61.1 | 65.3 | 67.6 | 73.5 | 75.7* | 67.4 |
| 13.7 | 2 - As above | H/W Pejepscot Paper Co. dam | 69.3 | 72.5 | 75.5 | 76.9 | 80.7 | 79.1* | 79.2* |
| 15.8 | 2 - As above | D/S U.S. Gypsum Co. dam | 75.6 | 79.6 | 83.2 | 85.1 | 90.2 | 86.6 | - |
| 16.1 | 2 - As above | H/W Worumbo Manufacturing Co. dam | 100.8 | 102.8 | 105.0 | 106.2 | 109.6 | 107.2 | 104.1 |
| 28.4 | 3 - Mouth, Sabattus River, RM 17.7 to mouth, Little Androscoggin River, RM 30.1 | USGS gage at Auburn | 120.9 | 126.9 | 132.4 | 135.0 | 141.0 | 136.8 | 132.8 |
| 30.6 | 4 - Mouth, Little Androscoggin River, RM 30.1 to Union Water Power Co. dam, Auburn, RM 30.8 | Route 202 Highway bridge | 130.2 | 135.1 | 140.3 | 143.1 | 150.00 | 144.9 | 140.5 |
| 30.8 | 5 - Union Water Power Co. dam, RM 30.8 to mouth, Nezinscot River, RM 44.9 | Union Water Power Co. dam | 169.7 | 172.0 | 175.0 | 176.6 | 181.0 | 177.6 | 174.2 |
| 33.6 | 5 - As above | Deer Rips dam | 207.4 | 209.7 | 212.0 | 213.3 | 216.5 | 210.3 | - |
| 34.8 | 5 - As above | Gulf Island dam | - | 262.0 | 263.0 | 264.7 | 267.8 | 265.6 | 264.2 |
| 59.8 | 6 - Mouth, Nezinscot River, RM 44.9 to International Paper Co. dam, Livermore Falls, RM 60.9 | River reach at 59.8 | 288.5 | 294.4 | 300.4 | 303.5 | 311.9 | 305.0 | 302.8 |

(continued on next page)

TABLE 9 (Continued)
ELEVATION-FREQUENCY DATA
ANDROSCOGGIN RIVER

| River Mile | Zone | Location | Elevation (Feet NGVD) 2-Year | 10-Year | 50-Year | 100-Year | 500-Year | 1936 | 1987 |
|---|---|---|---|---|---|---|---|---|---|
| 61.78 | 7 - International Paper Co. dam, RM 60.9 to Riley dam, International Paper Co., RM 66.6 | T/W Otis dam, International Paper Co. | 320.2 | 324.8 | 330.2 | 332.7 | 339.8 | 334.5 | 330.0 |
| 61.8 | 7 - As above | H/W Otis dam | - | 346.6 | 349.6 | 350.8 | 353.4 | 350.0 | 347.0 |
| 63.8 | 7 - As above | H/W International Paper Co. dam | - | 359.0 | 362.2 | 363.4 | 366.6 | - | 360.5 |
| 71.7 | 8 - Riley dam, RM 66.6 to mouth, Webb River, RM 81.8 | Route 140 Highway bridge | 384.7 | 389.8 | 394.6 | 396.4 | 400.8 | 397.4 | 395.0 |
| 85.75 | 9 - Mouth, Webb River, RM 81.8 to mouth, Swift River, RM 86.3 | Ridlonville Highway bridge | 425.4 | 429.3 | 433.7 | 435.9 | 441.9 | 437.8 | 435.8 |
| 87.1 | 10 - Mouth, Swift River, RM 86.3 to Route 120 Highway bridge, Rumford, RM 87.6 | D/S Morse bridge | - | 489.8 | 493.6 | 495.3 | 499.8 | - | - |
| 88.05 | 11 - Route 120 Highway bridge, RM 87.6 to mouth Concord River, RM 95 | Mouth to Logan Brook | 610.0 | 614.7 | 620.1 | 622.6 | 629.6 | 623.1 | 618.2 |
| | | LITTLE ANDROSCOGGIN RIVER | | | | | | | |
| 0.4 | 1 - Mouth, Little Androscoggin to D/S face Barker Mills dam, RM 0.0 - 0.72 | | - | 129.0 | 132.5 | 135.2 | - | 140.6* | - |
| 0.95 | 2 - From Barker Mills dam to Breached dam, RM 0.72 to 1.33 | | - | 169.2 | 172.0 | 173.5 | - | 176.3* | - |
| 1.70 | 3 - From Breached dam to former USGS gage, RM 1.33 to 5.1 | | - | 193.0 | 197.0 | 198.8 | - | 200.9 | - |
| 5.13 | 4 - From former USGS gage site to U/S corporate limit, RM 5.1 to 8.1 | | - | 217.5 | 221.8 | 224.9 | - | - | - |

* High watermark elevations appear high - validity questioned

Lower Richardson, Aziscohos, and Umbagog Lakes were obtained from the Union Water Power Company. Flood inflow hydrographs to these storage areas were computed using the reported average daily outflows and daily changes in lake storages in the continuity equation:

$$\text{INFLOW} = \text{OUTFLOW} + \Delta\ \text{STORAGE}$$

Resulting inflow hydrographs at the individual storages for the 1987 flood event are shown on plate 9. Because they are based on average daily outflow and change in reservoir storage, they are approximations only, with sketched hydrographs based on hydrologic engineering judgment.

c. Flood Routings. Flood hydrographs were routed downstream along the main stem of the Androscoggin from Errol to Rumford using the progressive average lag method of routing. For the reaches between Rumford and Auburn, a variable coefficient routing method was used (table 10 shows the routing coefficients used for each reach). The basin was divided into tributary and local subwatersheds for this analysis with the resulting watershed delineation shown on plate 1.

Routing coefficients were calculated initially by trial and error through reproduction of the 1936 and 1953 floods of record, and final selection was based on best-fit calibration with recorded flood hydrographs. Routed flood hydrographs for the 1936, 1953, and 1987 floods at Rumford and Auburn are shown on plates 6, 7, and 8, respectively.

d. Results. Peak discharge diagrams and tributary contributions for the 3 floods analyzed are also shown on plates 6, 7, and 8.

(1) Upstream of Errol. Due to the large amounts of storage above Errol, flood runoff from this area is greatly modified. Only during major floods is there any appreciable floodflow from this area. Although the 1,045-square mile drainage area above Errol Dam represents almost 50 percent of the watershed above Rumford, this area contributes less than 5 percent to peak flows at Rumford. Further downstream at Auburn, this 1,045-square mile drainage area represents almost one-third of the total watershed, but contributes less than 3 percent to the peak flow.

(2) Errol to Gorham. The net drainage area between Errol and Gorham is 318 square miles and represents 23 percent of the total watershed at this point. Peak flows at

TABLE 10

ANDROSCOGGIN RIVER BASIN
ROUTING COEFFICIENTS

| Routing Reach | Reach Limits: River Mile | Reach Limits: Description | Coefficients**: $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$* | Average*** (No. of Periods) | Lag*** (No. of Periods from Middle of Average) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| | 135 | USGS Gage, Gorham | - | | - | - | - | 2 | 1/2 |
| 2 | | | | | | | | | |
| | 130 | Mouth of Moose and Peabody Rivers | - | - | - | - | - | 2 | 1/2 |
| 3 | | | | | | | | | |
| | 120 | Mouth of Wild River | - | - | - | - | - | 5 | 3 |
| 4 | | | | | | | | | |
| | 104 | Mouth of Sunday and Bear Rivers | - | - | - | - | - | 2 | 1/2 |
| 5 | | | | | | | | | |
| | 97 | Mouth of Ellis River | - | - | - | - | - | 3 | 1 |
| 6 | | | | | | | | | |
| | 87 | USGS gage, Rumford (mouth of Swift River) | 0 | 0.1 | 0.2 | 0.7 | 0 | - | - |
| 7 | | | | | | | | | |
| | 82 | Mouth of Webb River | 0.1 | 0.25 | 0.5 | 0.15 | 0 | - | - |
| 8 | | | | | | | | | |
| | 62 | "Otis" dam, Chisholm, ME | 0.1 | 0.2 | 0.3 | 0.3 | 0.1 | - | - |
| 9 | | | | | | | | | |
| | 45 | Mouth of Nezinscot River | - | - | - | - | - | 3 | 1 |
| 10 | | | | | | | | | |
| | 29 | USGS gage, Auburn, ME (mouth of Little Androscoggin River) | | | | | | | |

* Basic routing equation: $O_4 = C_1I_1+C_2I_2+C_3I_3+C_4I_4+C_5I_5$

** Routing coefficients are applicable for instantaneous flows expressed in CFS for 6-hour intervals of time.

*** Lag-average coefficients are normally expressed as average/lag - "N" hour cfs.
Example: 3/1 - 6-hour CFS denotes an average of three instantaneous 6-hour CFS and a Lag of one 6-hour period.

Gorham tend to be generated by the local flow from this net area, with peak outflows from Errol Dam occurring a day or two later. This often results in a double peaked hydrograph at Gorham, with the second peak or outflow from storage generally being lower than the first. Runoff from this area contributes from 8 to 13 percent of flood peaks at Rumford and 6 to 7 percent at Auburn.

(3) Gorham to Rumford. The principal flood producing tributaries in this central portion of the basin which drain the slopes of the White Mountains are: the Moose, Peabody, Wild, Sunday, Bear, Ellis, and Swift Rivers. Their total drainage area is 643 square miles, or almost 20 percent of the total watershed area at Auburn. However, these tributaries contribute almost 40 percent to peak flows at Auburn. Contribution of the Ellis River is somewhat uncertain due to the fact that the lower portion of the river is very flat and has a large amount of natural storage. The main stem of the Androscoggin causes backwater flooding into this storage area and, therefore, retards floodflows from exiting the Ellis River. A gaging station was in operation from 1963 to 1982 on the Ellis River to aid in studying this phenomenon. Unfortunately, the gage has been discontinued and recorded Ellis River flow data for the 1987 flood is not available. The 1987 flood contribution from the Ellis was estimated by working backwards and subtracting out known flood hydrographs.

(4) Rumford to the Mouth. The Nezinscot and Little Androscoggin Rivers are the main flood contributing tributaries in the lower portion of the river basin, draining approximately 24 percent of the net (downstream of Errol) drainage area at Auburn, and contributing about 20 percent to the peak flows. Their peaks tend to be synchronous with the peak of the main stem Androscoggin. The gage on the lower portion of the Little Androscoggin River at Auburn was discontinued in 1982; however, recorded data is available at an upstream gaging station. Flood hydrograph data at this location for the 1987 flood was determined using recorded data at the upstream gage on the Little Androscoggin, prorating by a drainage area ratio, and calibrating the peak timing based on timing of recorded flood hydrographs on the Little Androscoggin at Auburn for the 1936 and 1953 flood events.

Table 11 lists the component contributions to peak floodflows, in percent, at Gorham, Rumford, and Auburn for the 1936, 1953, and 1987 flood events.

9. FLOOD CONTROL ALTERNATIVES

a. Local Protection Projects. During past Corps

TABLE 11

ANDROSCOGGIN RIVER BASIN
COMPONENT CONTRIBUTIONS TO
ANDROSCOGGIN RIVER FLOOD PEAKS

| Location | Contributing Component | Drainage Area (sq mi) | Drainage Area (%) | Percent Contribution to Peak Flow: March 1936 | March 1953 | March/April 1987 | Average |
|---|---|---|---|---|---|---|---|
| Gorham, NH | Androscoggin at Errol | 1,045 | 76.7 | 28.8 | 13.0 | 16 | 19.3 |
| | Local--Errol to Gorham | 318 | 23.3 | 71.2 | 87.0 | 84 | 80.7 |
| | | 1,363 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Rumford, ME | Androscoggin at Errol | 1,045 | 50.5 | 5.5 | 1.8 | 7.5* | 13.7* |
| | Local--Errol to Gorham | 318 | 15.4 | 13.8 | 12.6 | | |
| | Moose & Peabody Rivers | 95 | 4.6 | 17.4 | 8.2 | 3.0 | 9.6 |
| | Wild & Local | 134 | 6.4 | 20.4 | 12.9 | 15.0 | 16.1 |
| | Sunday & Bear Rivers | 94 | 4.6 | 9.8 | 14.7 | 21.0 | 15.2 |
| | Local Areas | 121 | 5.9 | 14.4 | 18.7 | 21.0 | 18.0 |
| | Ellis & Local | 195 | 9.5 | 15.7 | 21.2 | 19.5 | 18.8 |
| | Local Area | 65 | 3.1 | 3.0 | 9.8 | 13.0 | 8.6 |
| | Total | 2,067 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Auburn, ME | Androscoggin at Errol | 1,045 | 32.2 | 3.1 | 6.5 | 6.1* | 8.1* |
| | Local--Errol to Gorham | 318 | 9.7 | 7.7 | 1.0 | | |
| | Moose & Peabody Rivers | 95 | 2.9 | 8.3 | 4.1 | 3.9 | 5.5 |
| | Wild & Local | 134 | 4.1 | 10.0 | 6.2 | 9.2 | 8.5 |
| | Sunday & Bear | 94 | 2.9 | 5.2 | 6.6 | 9.3 | 7.0 |
| | Local Areas | 121 | 3.7 | 7.5 | 8.3 | 10.0 | 8.6 |
| | Ellis & Local | 195 | 6.0 | 9.4 | 10.1 | 7.3 | 9.0 |
| | Local | 65 | 2.0 | 2.4 | 4.4 | 5.0 | 3.9 |
| | Swift River | 125 | 3.8 | 9.7 | 7.5 | 9.6 | 8.9 |
| | Webb River | 145 | 4.5 | 4.0 | 3.7 | 5.7 | 4.5 |
| | Local Areas | 323 | 9.9 | 8.8 | 8.9 | 12.9 | 10.2 |
| | Nezinscot River | 181 | 5.6 | 7.0 | 13.5 | 7.8 | 9.4 |
| | Local Area | 63 | 1.9 | 3.0 | 2.7 | 2.5 | 2.7 |
| | Little Androscoggin R. | 353 | 10.8 | 13.9 | 16.6 | 10.7 | 13.7 |
| | Total | 3,257 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

* Total to Gorham, DA = 1,363 square miles

studies, local protection projects were screened for 10 sites within the Androscoggin Basin. At that time these projects were found economically unfeasible. New studies were not undertaken during this investigation. Updated stage-frequency curves were provided to Planning Division at all locations to determine current economic feasibility.

b. Flood Control Reservoirs. No new flood control reservoir sites were studied during this investigation. The following reservoir sites showed the most promise during past investigations as studied in the 1967 Survey Report.

(1) Pontook Dam. The Pontook project consisted of a dam and reservoir, along with a reregulating dam and reservoir located on the Androscoggin River approximately 12 miles upstream of Berlin, New Hampshire. The Pontook dam would have been a multipurpose power, flood control and recreation project, operated in conjunction with the storages in the Rangeley Lakes system. Total gross storage capacity at the project would have been 238,000 acre-feet. In the spring, a minimum of 98,400 acre-feet of storage would have been provided by Pontook for flood control, equivalent to 10.9 inches of runoff from its net drainage area of 170 square miles. The Rangeley Lake system is operated to maintain a flow of 1,550 cfs at Berlin, New Hampshire. This operation results in the seasonal drawdown of the storages, generally beginning in June, and on average, resulting in about 185,000 acre-feet of storage available each spring. The lakes are then maintained drawn down with the 1,550 cfs requirement being provided by releases from Errol dam and runoff of the unregulated downstream tributaries. The resulting 185,000 acre-feet of incidental flood control storage in Rangeley Lakes, together with the 98,400 acre-feet of flood control storage in Pontook, would result in about 284,000 acre-feet of total storage available. This storage is equivalent to about 4.4 inches of runoff over the 1,215-square mile drainage area.

Pontook dam would have had a maximum height of 106 feet, with top of dam at elevation 1,230 feet NGVD and an ogee weir spillway at elevation 1,180 feet NGVD. Full pool would have had a surface area of 7,470 acres at elevation 1,220 feet NGVD. With this project in operation, average stage reduction (based on 1987 discharges) at Auburn for a significant flood event would have been about 0.9 foot. For the 1936 flood, the stage reduction at Auburn would have been 0.6 foot.

With power development at Pontook at a low load factor, a second dam would have been needed approximately 6.5 miles downstream to reregulate the peak turbine discharges to usable flows for downstream power plants. This dam would have been 53 feet high (elevation 1,136 feet NGVD), with full pool at elevation 1,121 feet NGVD and a 16,300-acre-foot capacity.

Although this project was economically justified, it was never authorized due to public opposition.

(2) Ellis Dam and Reservoir. The Ellis dam and reservoir project would have been located on the Ellis River in Rumford, Maine, approximately one mile upstream of its confluence with the Androscoggin River. This site was studied for flood control alone, flood control and recreation, and flood control, recreation, and power. The project would have consisted of a rolled earth dam with a maximum height ranging between 56 to 65 feet (elevations 671 to 680 feet NGVD) depending on the chosen project purpose, and a chute spillway between elevations 642 to 660 feet NGVD. A total of 90,000 acre-feet of flood control storage, equivalent to 8 inches of runoff from the 164-square mile project drainage area, would have been available with any of the three project scenarios. Average stage reduction at Auburn would have been about 1.0 foot with this project in operation.

As mentioned previously, floodflows along the Androscoggin tend to cause water to flow upstream at the mouth of the Ellis River and into natural storage areas. Sufficient hydrologic information was not available to adequately analyze this phenomena, which was a concern. This project was dropped from further study due to lack of economic justification.

(3) Roxbury Project. This single-purpose flood control project would have been located on the Swift River in Roxbury, Maine, approximately 11 miles above the mouth. The dam would have been 112 feet high (elevation 830 feet NGVD) and 2,000 feet long, with a spillway at elevation 810 feet NGVD. Approximately 36,300 acre-feet would have been impounded for flood control storage, equivalent to 8-1/2 inches of runoff from the 80-square mile drainage area. Average stage reduction of approximately 0.8 foot would have occurred downstream in Auburn. The project was not economically justified.

(4) Hale Project. The Hale project site would have been located on the Swift River, approximately 2 miles above the mouth in Mexico, Maine. Two alternatives were looked at -- one with flood control only, and the second, with flood control, power, and recreation.

For the multipurpose project, a 255 foot high dam would have been constructed to elevation 784 feet NGVD, with a spillway at elevation 763 feet NGVD. Drainage area at the project would have been 111 square miles. Total storage would have been 332,000 acre-feet, with 47,400 allotted to flood control, and 96,600 for power. An average of about 1.2 feet of stage reduction could have been realized downstream in Auburn. A reregulating dam would have been needed approximately one mile downstream, with a maximum height of 52 feet (elevation 500 feet), spillway crest at elevation 486 feet, and a 40-acre pool. Benefit/cost ratios were close to one; however, the project was not studied further.

c. Nonstructural. A flood warning system is being evaluated by Planning Division as a component of nonstructural flood reduction measures. The study project manager, through private contract, developed a computer model of the basin capable of reproducing the 1987 flood. Flood development within the Androscoggin Basin is complex and varies depending on areal extent of rainfall and antecedent conditions. Many of the smaller mountainous tributaries can produce extremely rapid runoff, resulting in localized flooding. Main stem river peaks, however, usually are somewhat delayed. Estimated warning times for use in reconnaissance level efforts as developed by this office are listed below:

| Androscoggin River | Estimated Warning Time |
|---|---|
| At Rumford | 18 to 24 hours |
| At Auburn | 24 to 30 hours |

For further discussion of this subject, see the main report of the Androscoggin River Reconnaissance Study.

## 10. SUMMARY AND CONCLUSIONS

The Androscoggin River Basin is subject to both frequent and major flooding as a result of meteorological events, i.e., coincident rainfall with snowmelt, successive rainfall events, or intense rainfall on frozen ground.

The upper portion of the basin, above Errol, New Hampshire, has a large amount of usable storage (660,500 acre-feet, equivalent to 12 inches of runoff from the 1,045-square mile drainage area) that greatly modifies floodflow from this area. The storage areas are a system of six lakes, owned and operated by the Union Water Power Company for downstream power and recreation flow requirements. Although this area represents 50 percent of the total watershed area above

Rumford and approximately 33 percent above Auburn, it contributes less than 5 and 3 percent, respectively, to peak flows at Rumford and Auburn.

Tributaries within the central portion of the basin, between Errol and the mouth of the Webb River, tend to generate the flood peak on the main stem of the Androscoggin River. In downstream order, they are: the Moose, Peabody, Wild, Sunday, Bear, Ellis, and Swift Rivers. These tributaries contribute almost 40 percent to peak flows at Auburn. Measures to reduce or desynchronize floodflows from these tributaries would be most beneficial from a flood control point of view, if found to be cost effective.

The Nezinscot and Little Androscoggin Rivers are the main tributaries contributing to floodflows (approximately 20 percent to peak flows) in the lower portion of the basin. Flood reducing or retarding structures, if cost effective, could also be beneficial here.

Measures to relieve damages in high risk and developed areas within the basin, whether structural or nonstructural (such as a more effective flood warning system) should be studied further.

11. REFERENCES

a. Corps of Engineers, Northeast Flood Study, "Report on Review of Survey or Flood Control and Allied Purposes, Androscoggin River Basin, Maine and New Hampshire," Volume II, June 1967.

b. New England-New York Inter-Agency Committee, "The Resources of the New England-New York Region," Part Two, Chapter VII, Androscoggin River Basin, Maine-New Hampshire, 1955.

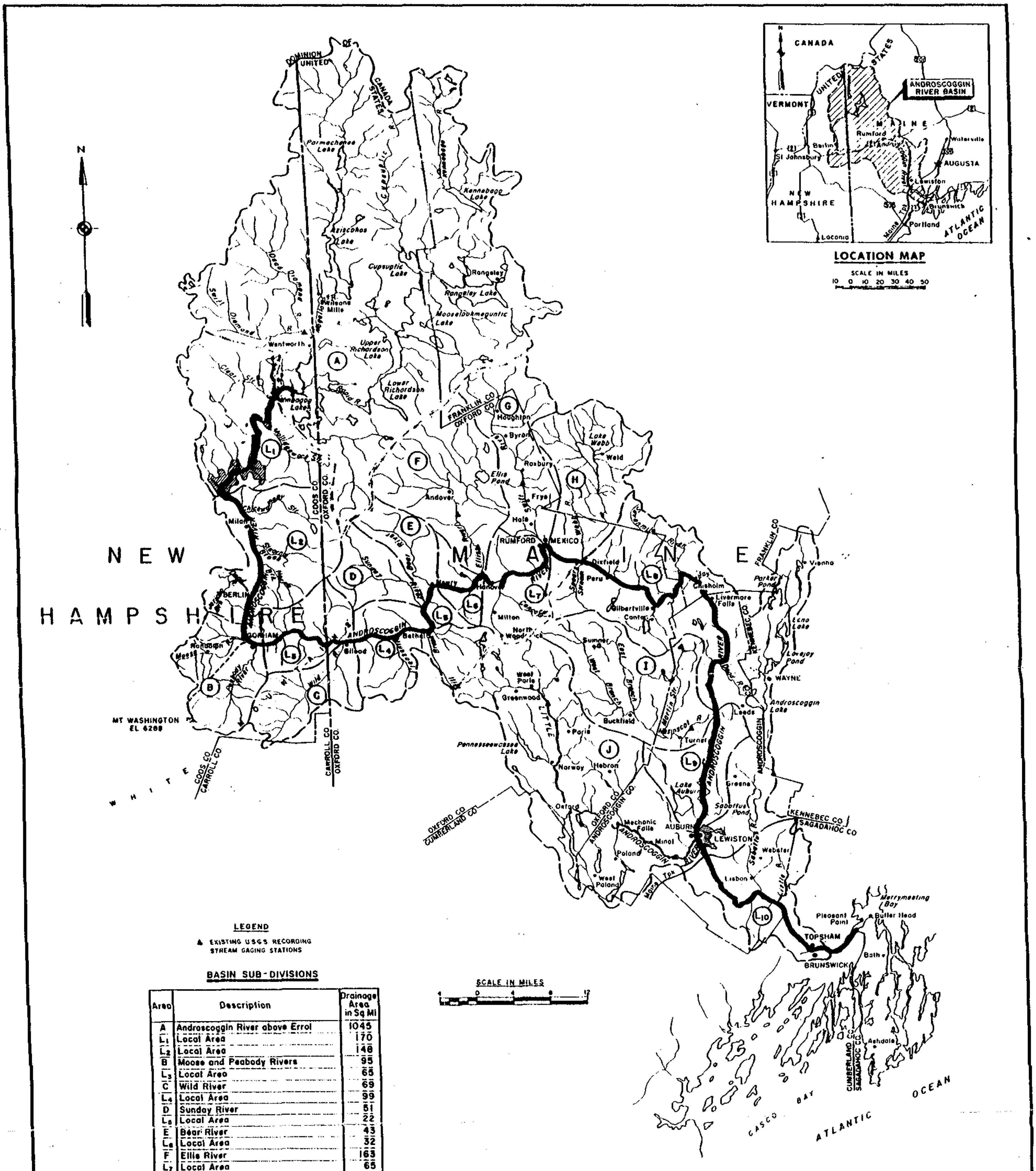
c. New England River Basins Commission, "Androscoggin River Basin Overview," December 1980.

d. U.S. Interagency Advisory Committee on Water Data, Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," March 1982.

e. Flood of April 1987, In Maine, Massachusetts and New Hampshire, U.S. Geological Survey Open-File Report 87-460.

f. Federal Power Commission, "Androscoggin River Basin, Maine and New Hampshire," Appendix 1, July 1963.

g. Federal Emergency Management Agency, Flood Insurance Studies for the Communities of: Rumford, Mexico, Canton, Peru, Jay, Lewiston, Auburn, Topsham, and Brunswick, Maine, Various Dates.




## BASIN SUB-DIVISIONS

| Area | Description | Drainage Area in Sq Mi |
|---|---|---|
| A | Androscoggin River above Errol | 1045 |
| $L_1$ | Local Area | 170 |
| $L_2$ | Local Area | 148 |
| B | Moose and Peabody Rivers | 95 |
| $L_3$ | Local Area | 65 |
| C | Wild River | 69 |
| $L_4$ | Local Area | 99 |
| D | Sunday River | 51 |
| $L_5$ | Local Area | 22 |
| E | Bear River | 43 |
| $L_6$ | Local Area | 32 |
| F | Ellis River | 163 |
| $L_7$ | Local Area | 65 |
| G | Swift River | 125 |
| H | Swift River plus Local Area | 145 |
| $L_8$ | Local Area | 323 |
| I | Nezinscot River | 181 |
| $L_9$ | Local Area | 63 |
| J | Little Androscoggin River | 353 |
| $L_{10}$ | Local Area | 173 |
| | Androscoggin River above Brunswick | 3450 |

US ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

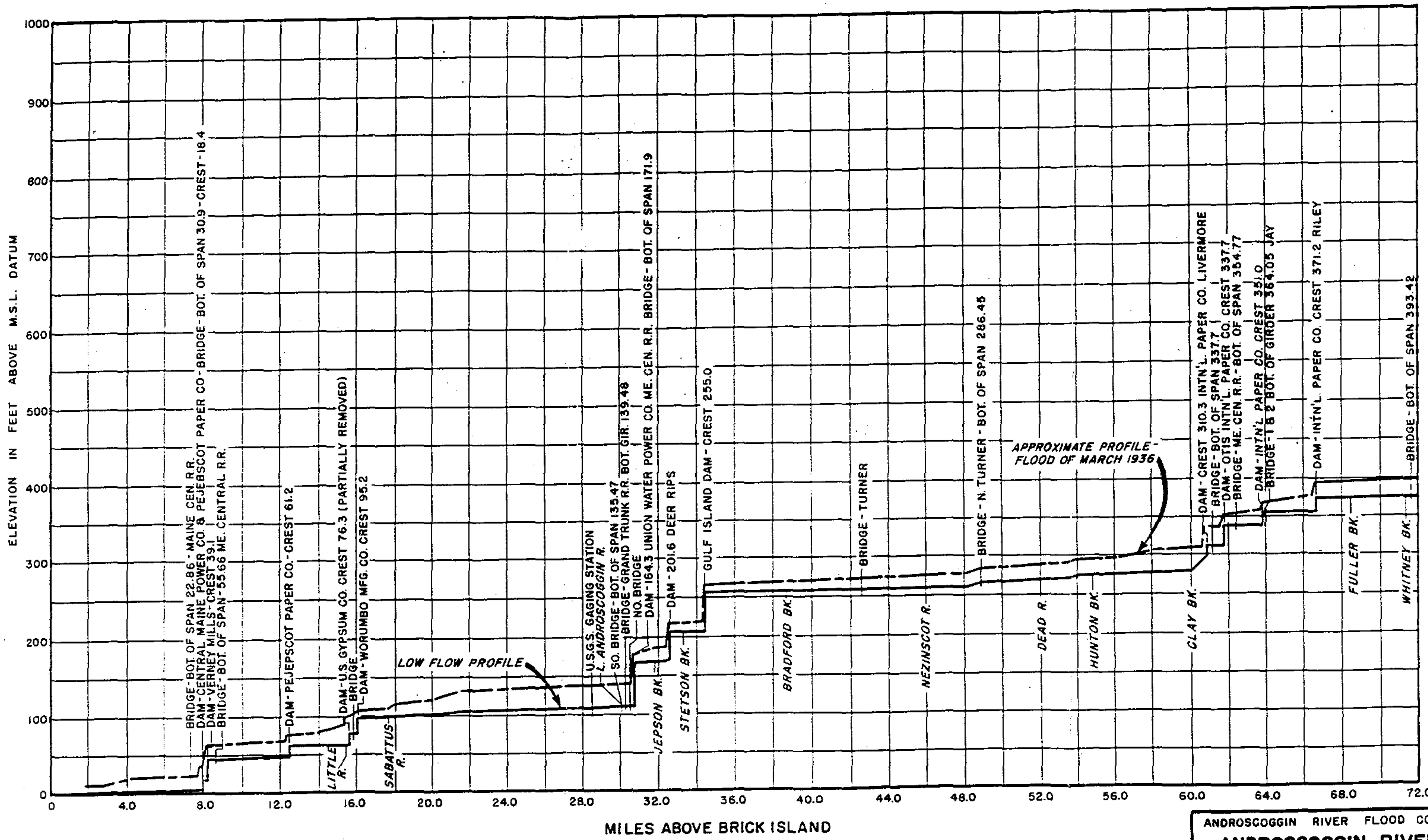
ANDROSCOGGIN RIVER FLOOD CONTROL

BASIN MAP

ANDROSCOGGIN RIVER, MAINE & N H

APPROVED
DATE
CHIEF, ENGINEERING DIV
CHIEF, PLANS & RPTS BRANCH
SCALE AS SHOWN
DRAWING NUMBER
SHEET 1 OF 1

PLATE 1




ANDROSCOGGIN RIVER FLOOD CONTROL

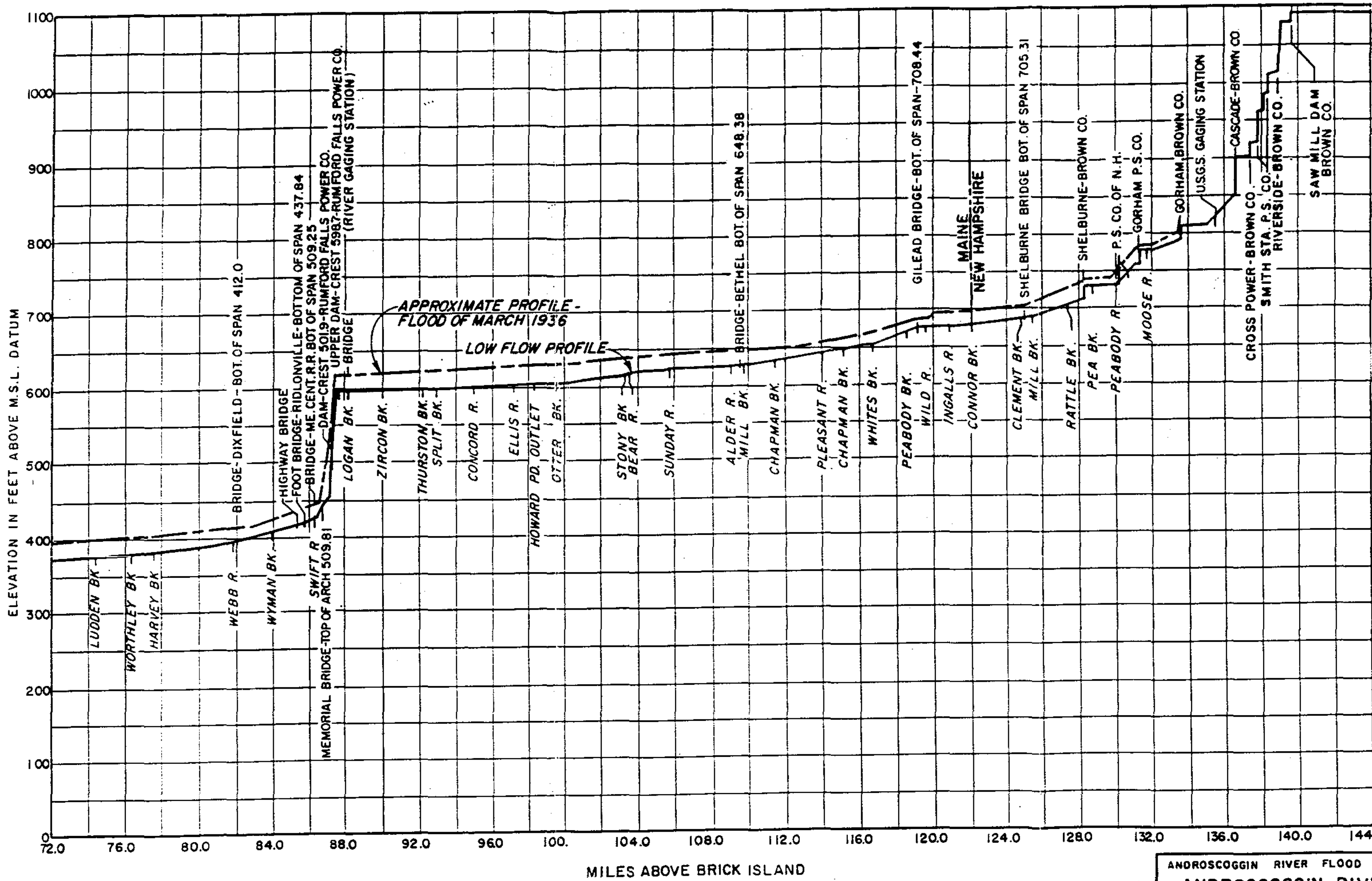
**ANDROSCOGGIN RIVER PROFILE**

ANDROSCOGGIN RIVER MAINE & N.H.

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

ARMY N.E.D. BOSTON OCTOBER 7, 1962

**PLATE** 2.A



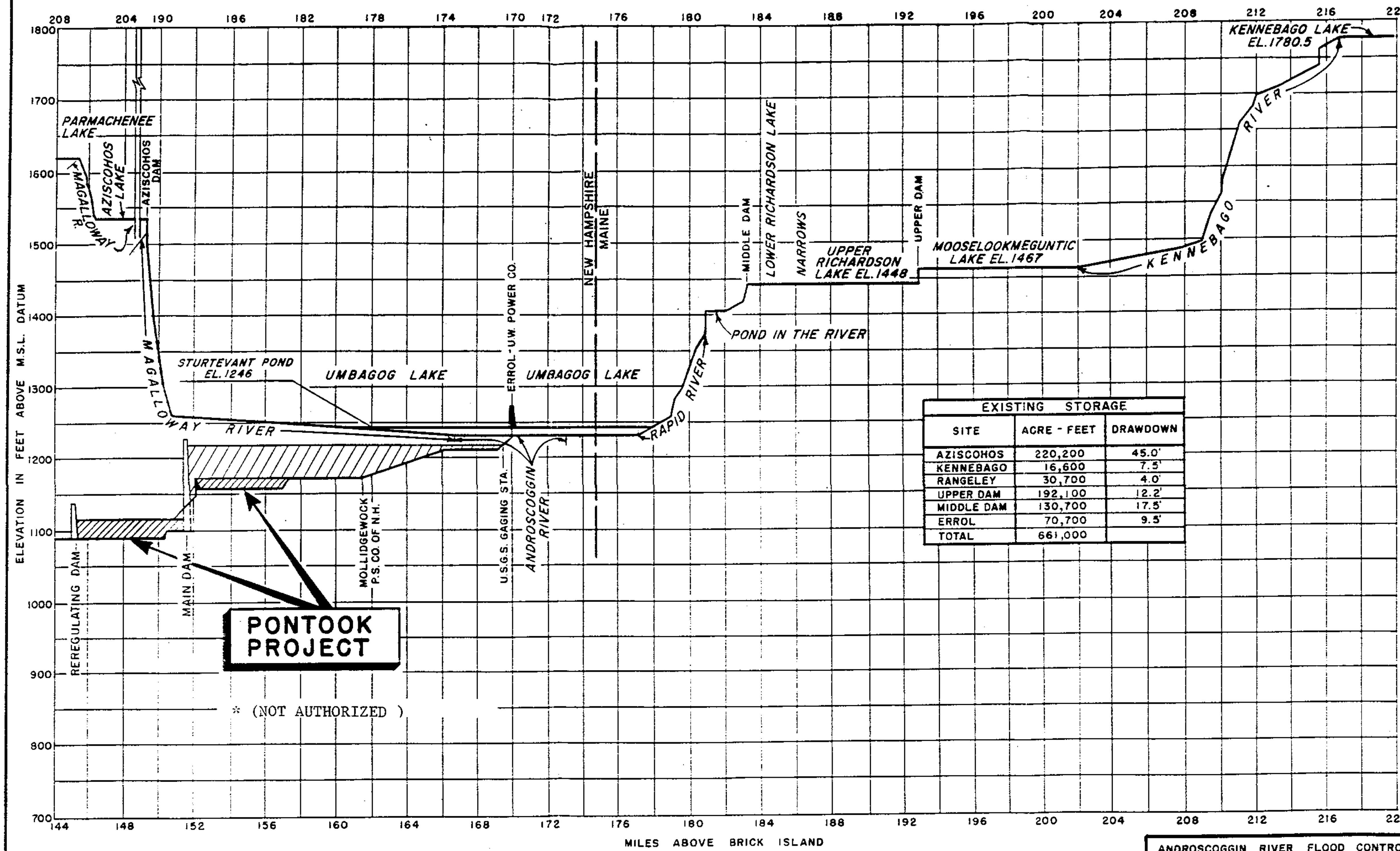

ANDROSCOGGIN RIVER FLOOD CONTROL

**ANDROSCOGGIN RIVER PROFILE**

ANDROSCOGGIN RIVER MAINE & N.H.

U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

**PLATE 2 B**




| EXISTING STORAGE | | |
|---|---|---|
| SITE | ACRE - FEET | DRAWDOWN |
| AZISCOHOS | 220,200 | 45.0' |
| KENNEBAGO | 16,600 | 7.5' |
| RANGELEY | 30,700 | 4.0' |
| UPPER DAM | 192,100 | 12.2' |
| MIDDLE DAM | 130,700 | 17.5' |
| ERROL | 70,700 | 9.5' |
| TOTAL | 661,000 | |

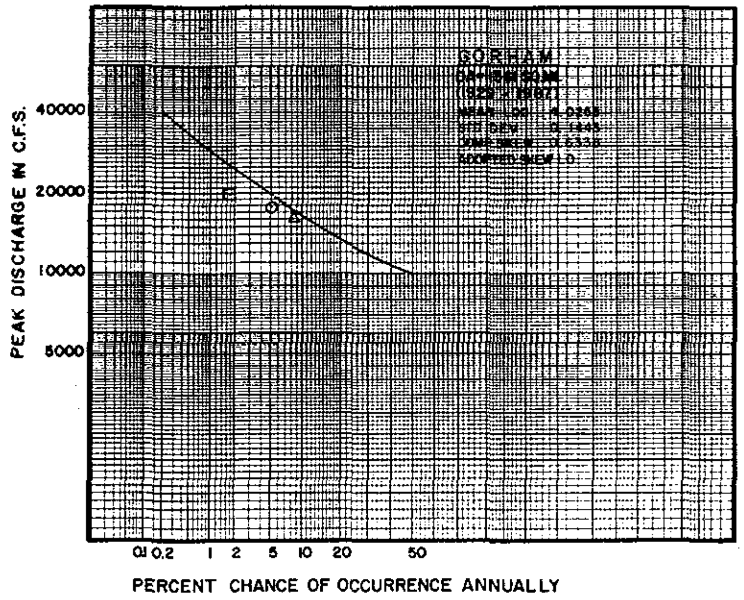
ANDROSCOGGIN RIVER FLOOD CONTROL

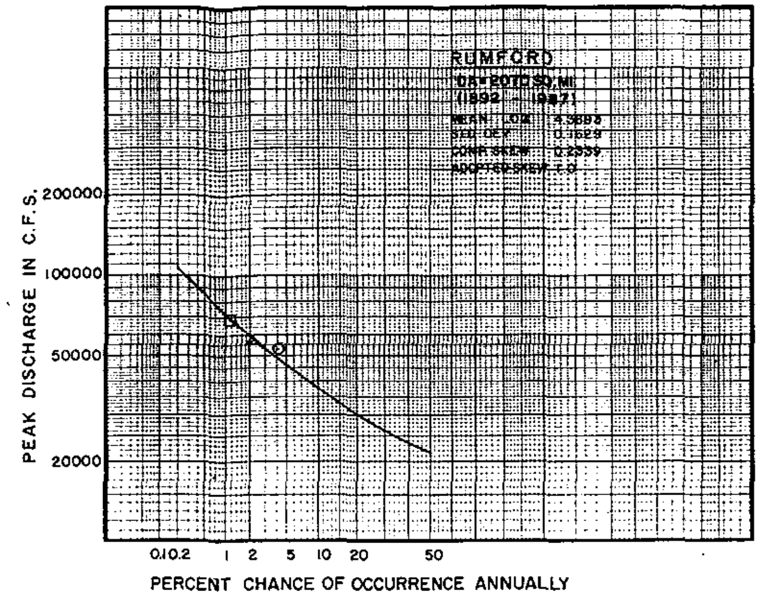
**ANDROSCOGGIN RIVER PROFILE**

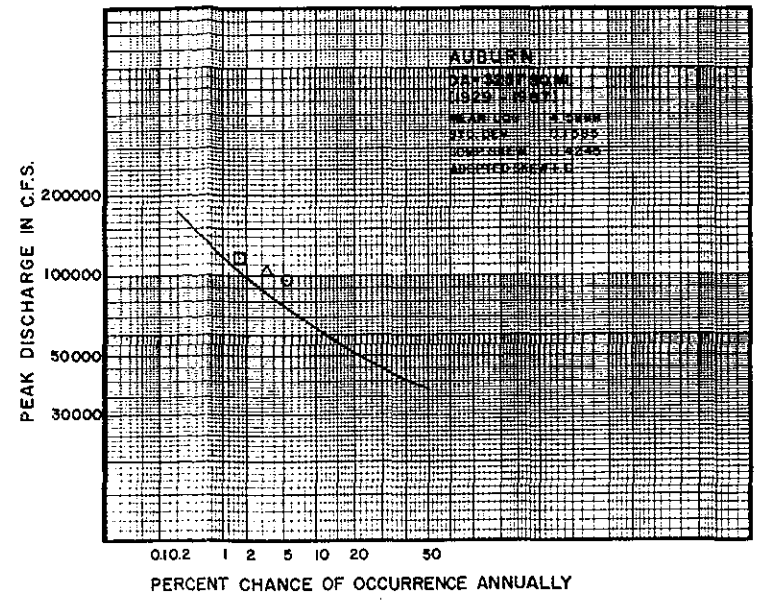
ANDROSCOGGIN RIVER MAINE & N.H.

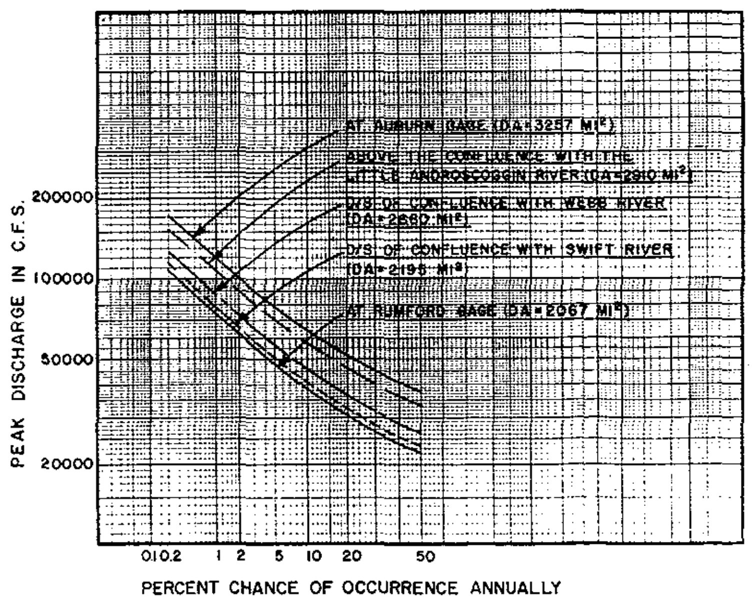
U.S. ARMY ENGINEER DIVISION
NEW ENGLAND
WALTHAM, MASS.

**PLATE** 2 C




LEGEND

- □ 1936
- △ 1987
- ⊙ 1953

DEPARTMENT OF THE ARMY
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WALTHAM, MASS.

# PEAK DISCHARGE FREQUENCIES

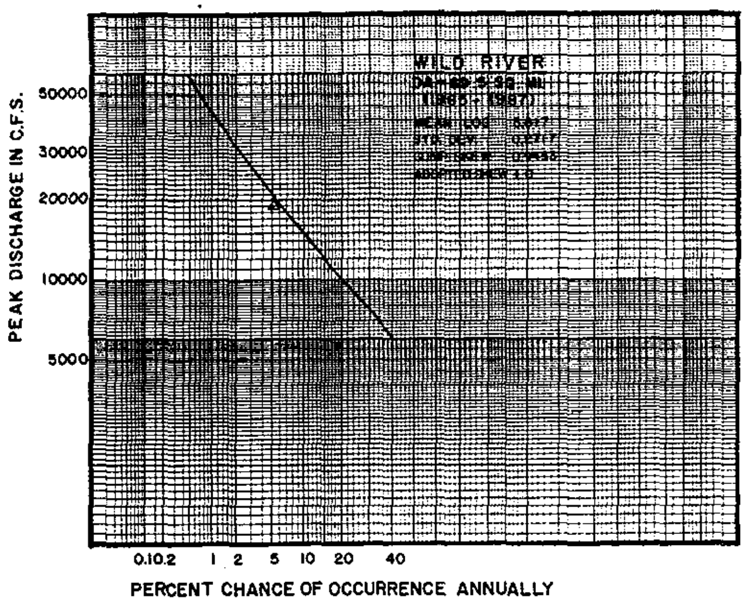
## MAIN STEM

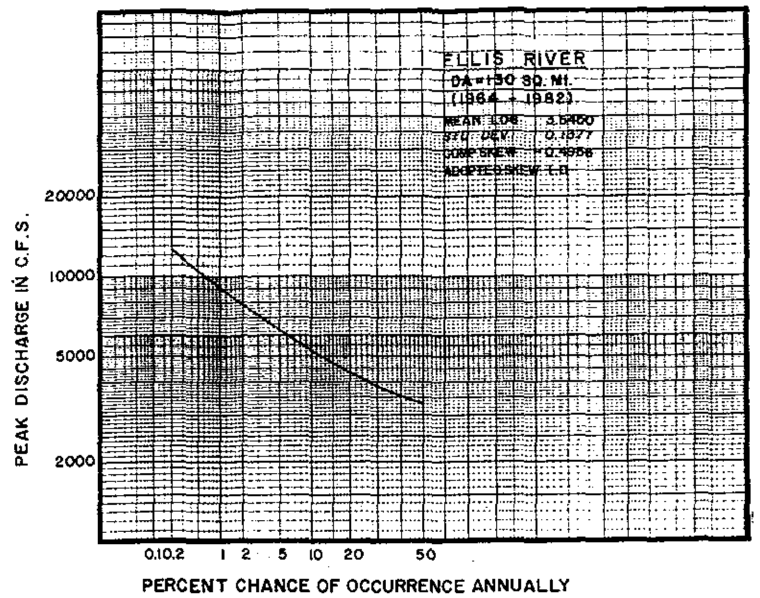
ANDROSCOGGIN RIVER

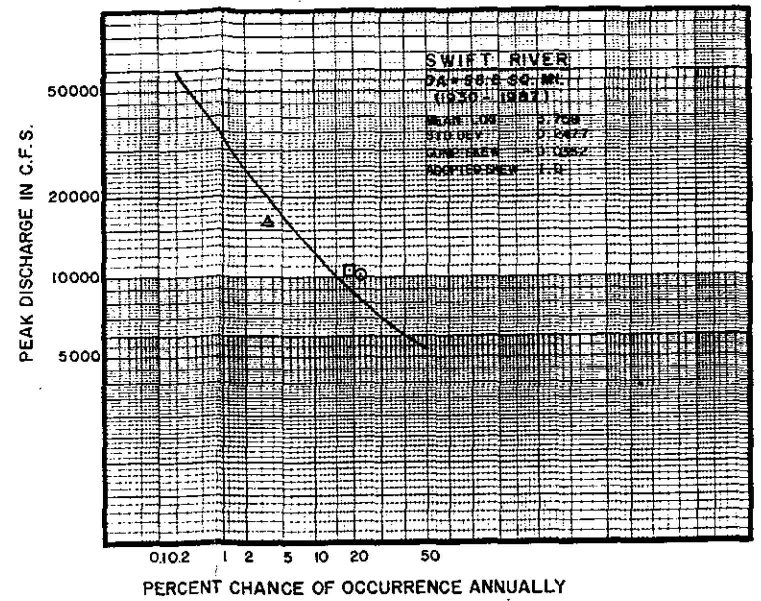
HES

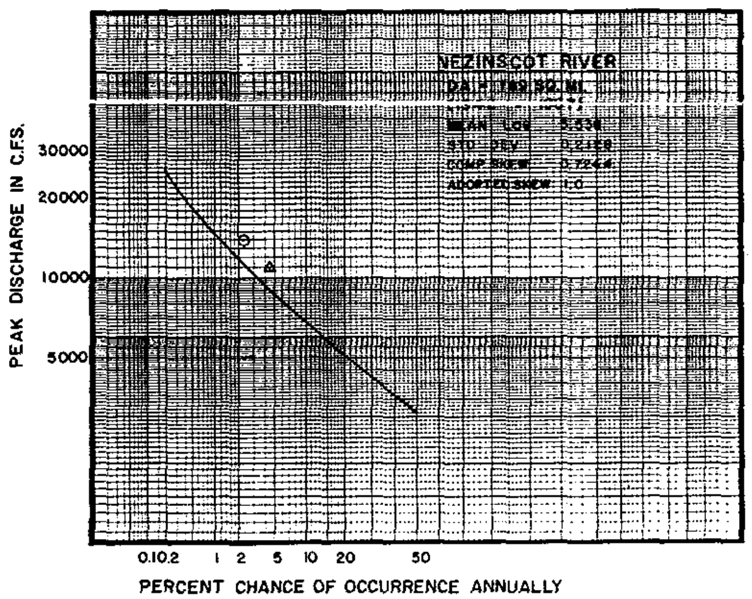
FEB. 1989

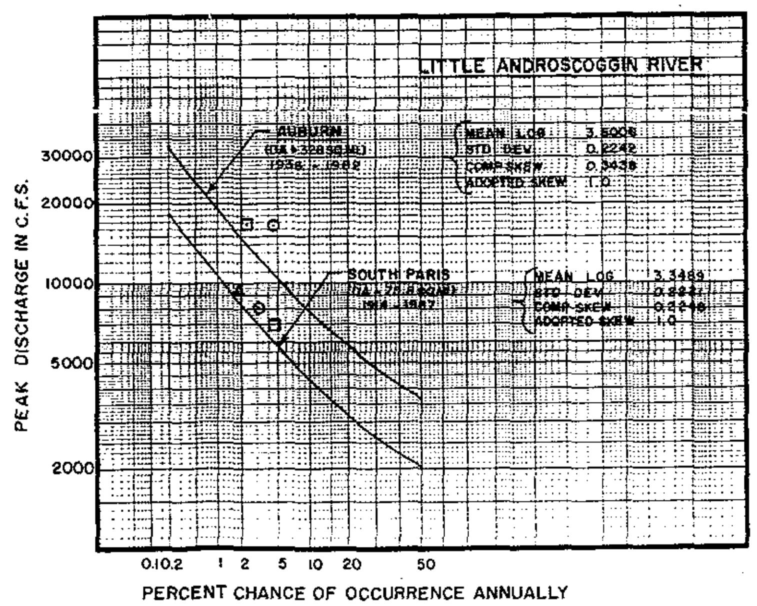
PLATE 3




LEGEND

- ⊡ 1936
- △ 1987
- ⊙ 1953

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WALTHAM, MASS.

**PEAK DISCHARGE**

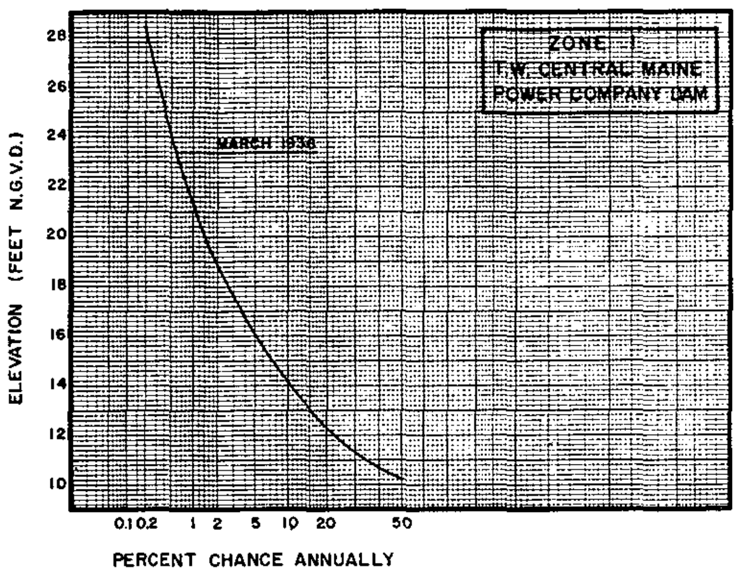
**FREQUENCIES**

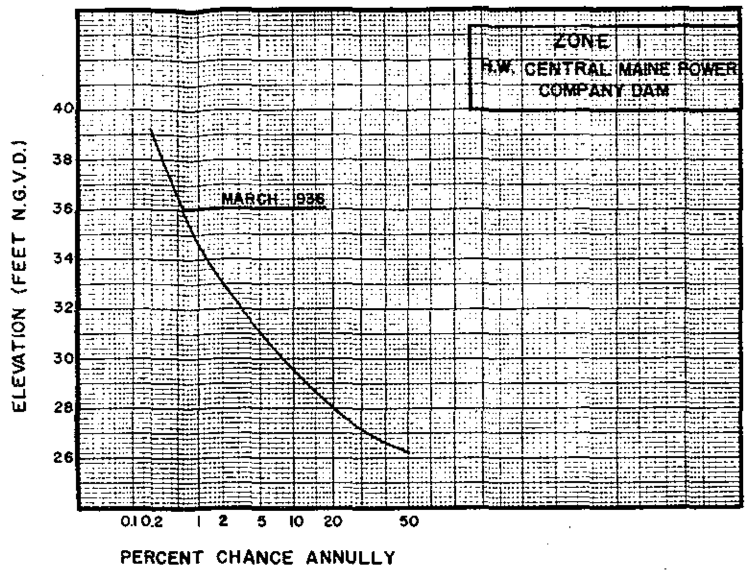
**TRIBUTARY WATERSHEDS**

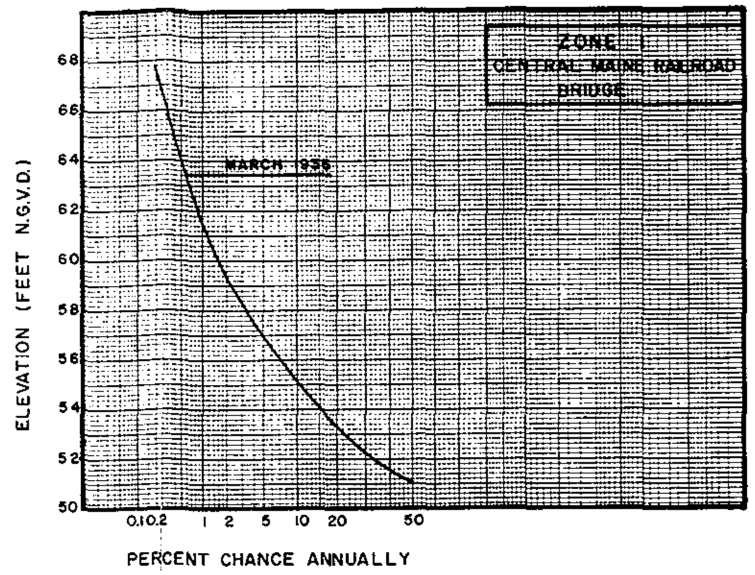
HES

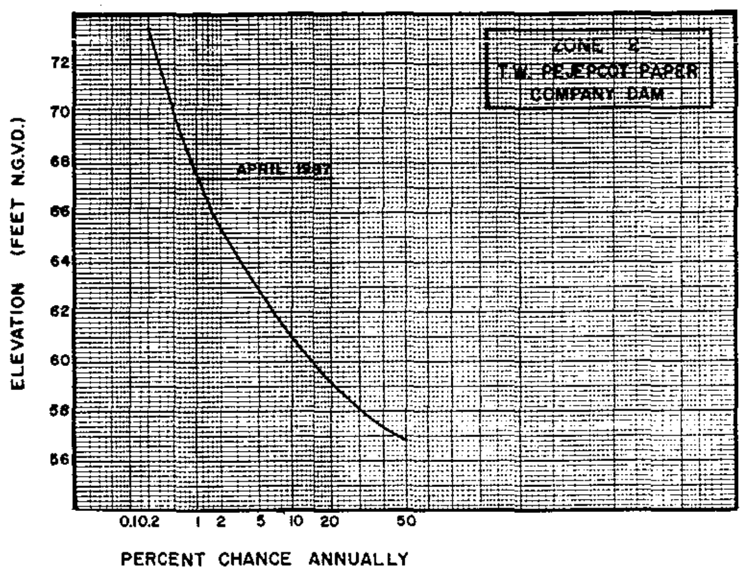
FEB. 1989

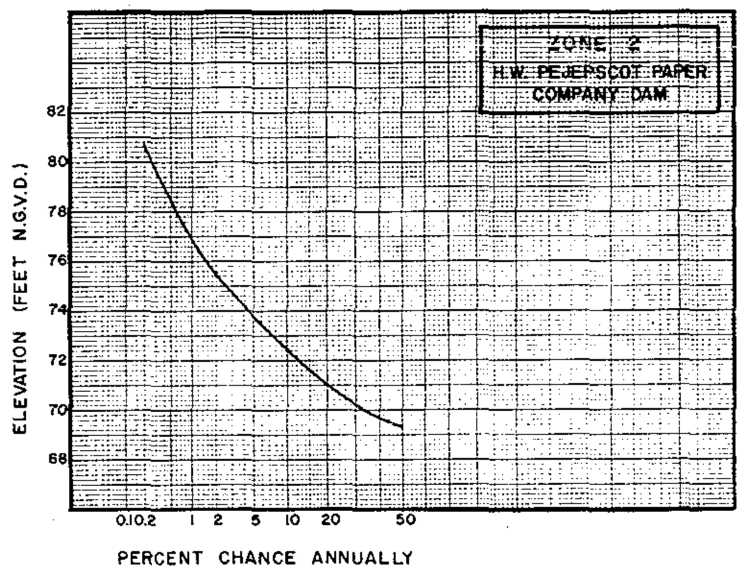
PLATE 4

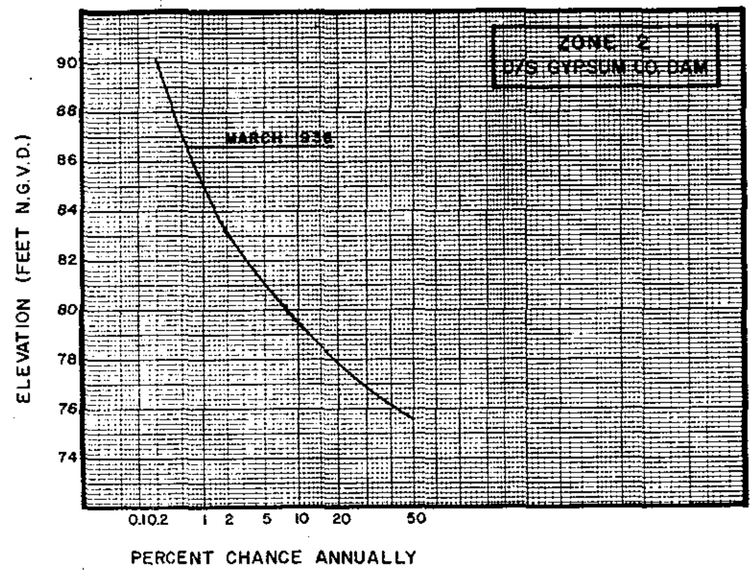


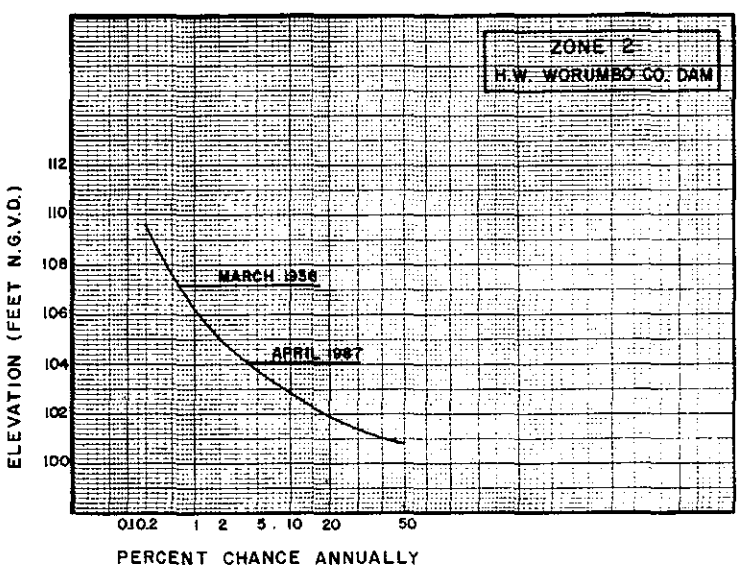



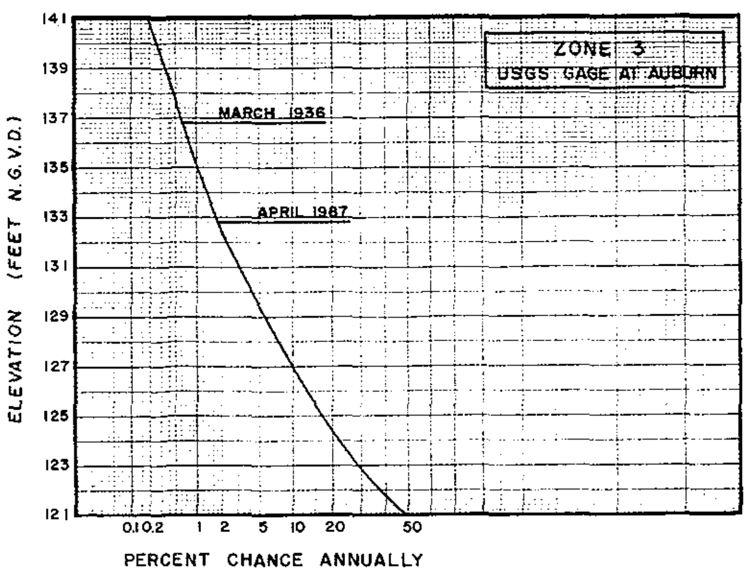




**NOTE:**

MARCH 1936 FLOOD LEVELS AFFECTED BY ICE JAMS.

DEPARTMENT OF THE ARMY
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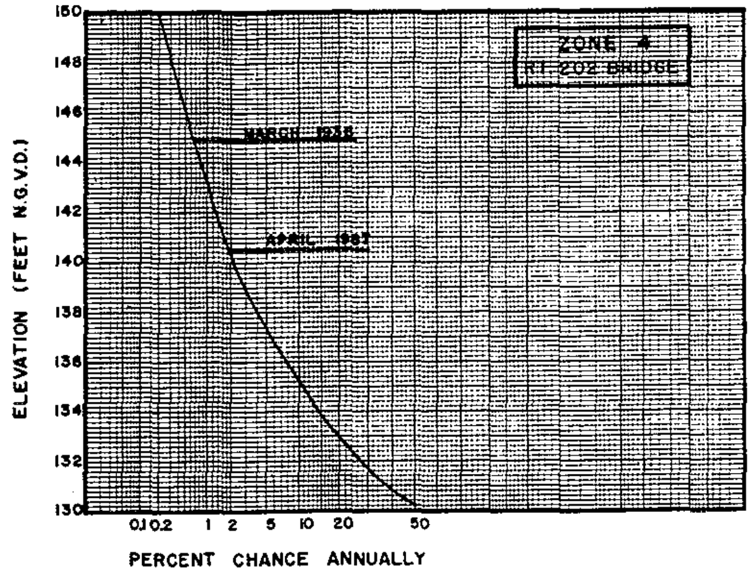
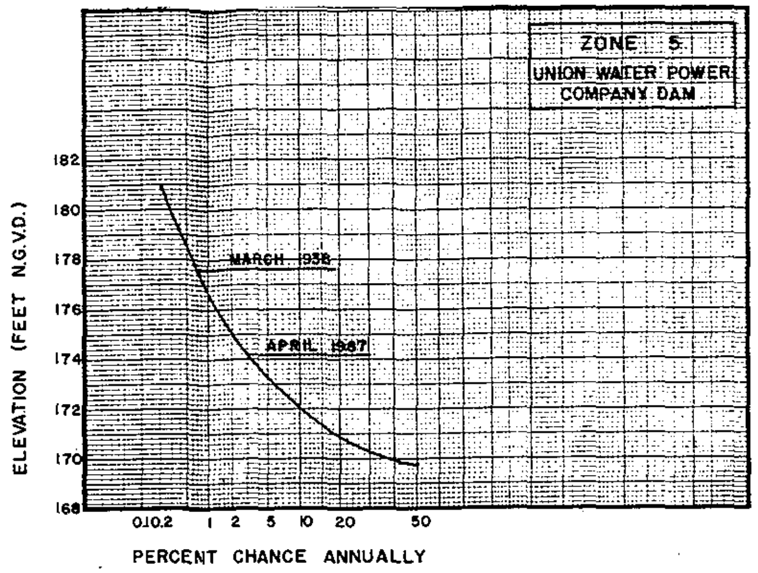
## STAGE FREQUENCY CURVES

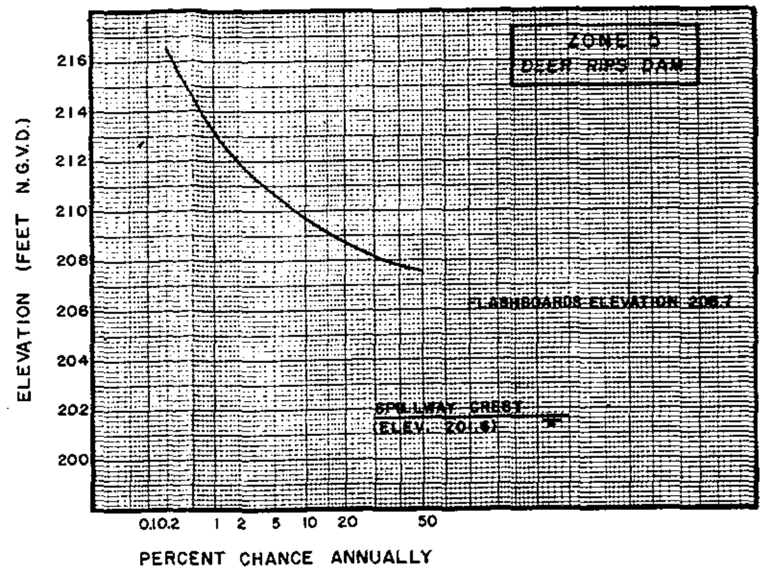
ANDROSCOGGIN RIVER

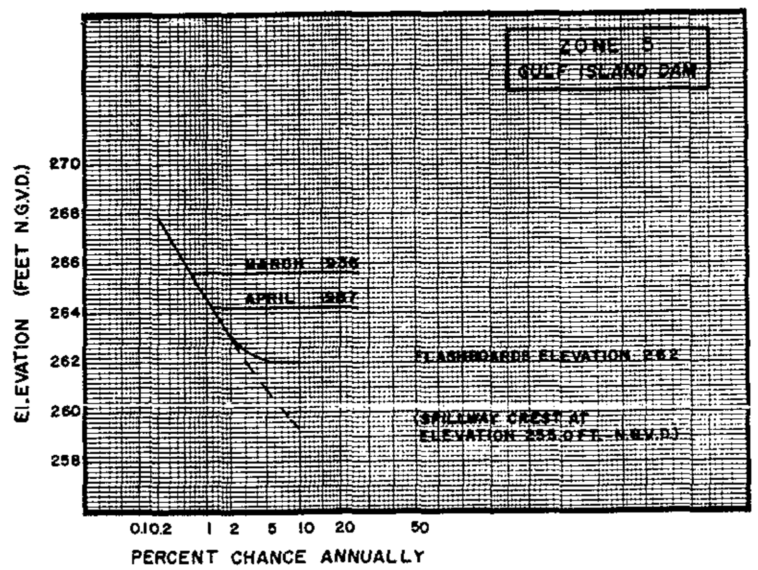
HES JAN. 1989

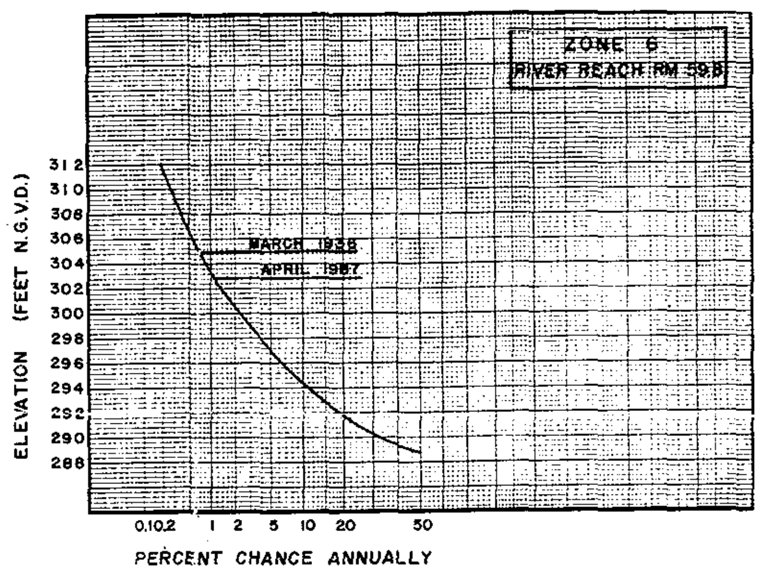
PLATE 5A

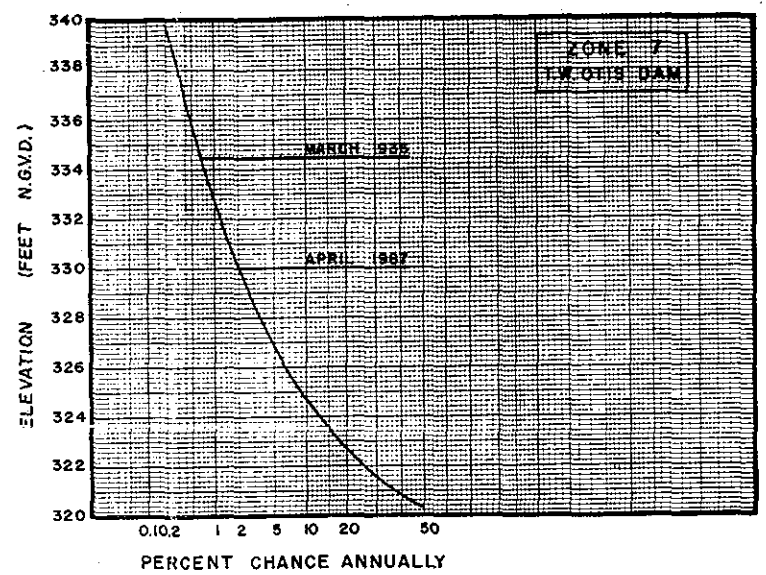


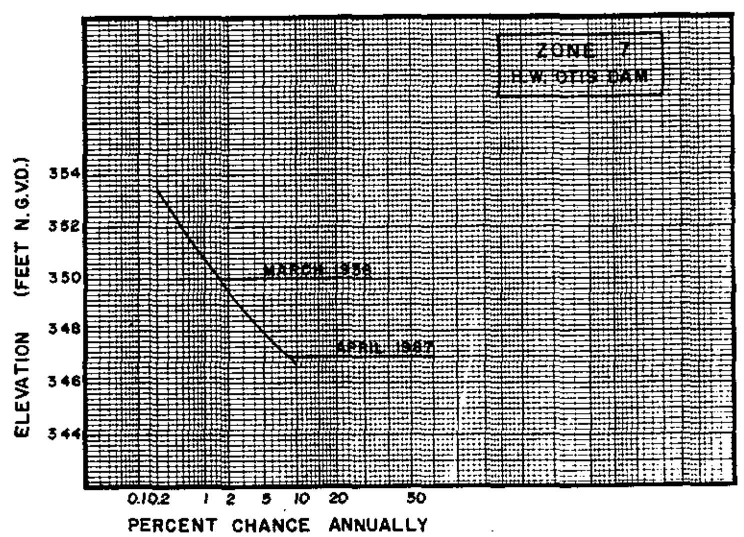



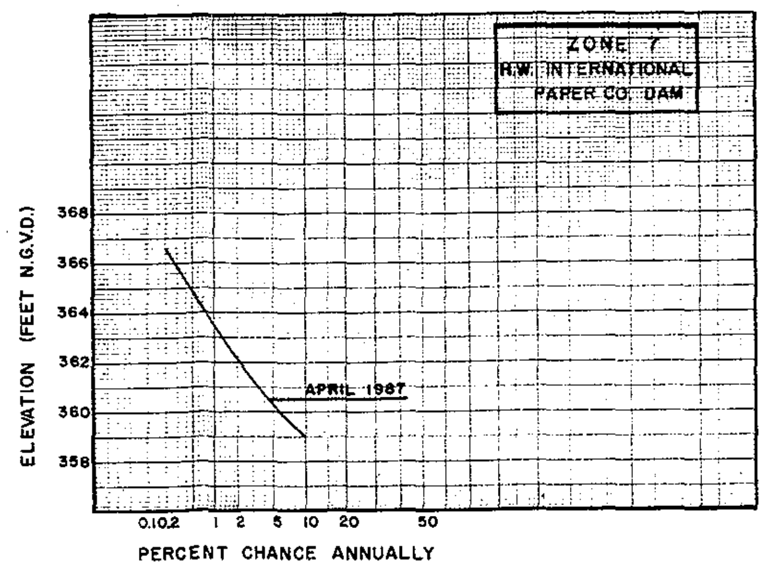




DEPARTMENT OF THE ARMY
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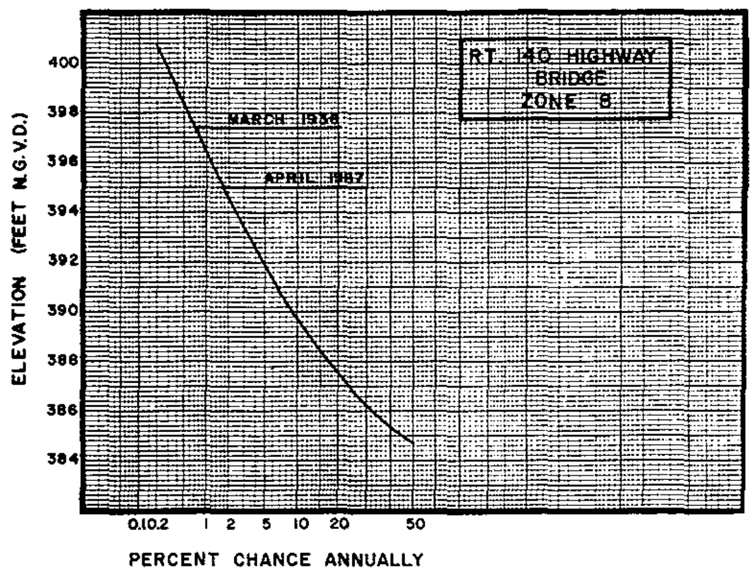
WALTHAM, MASS.

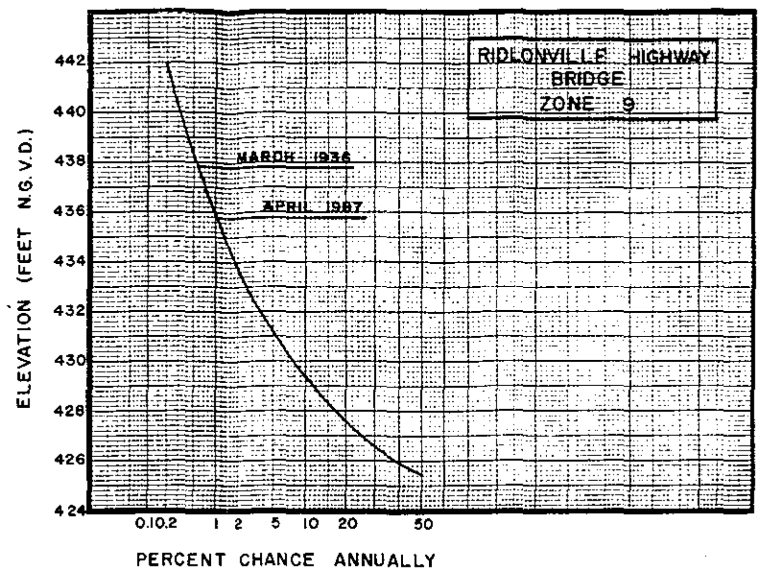
# STAGE FREQUENCY CURVES

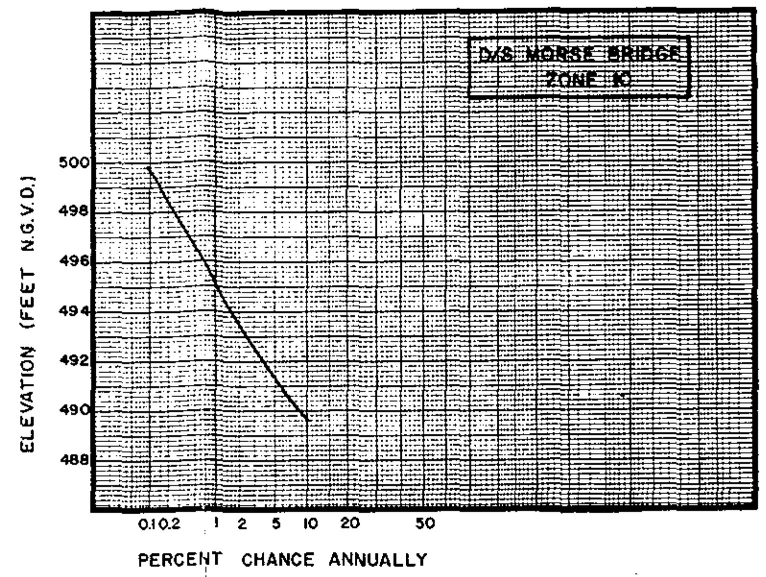
ANDROSCOGGIN RIVER

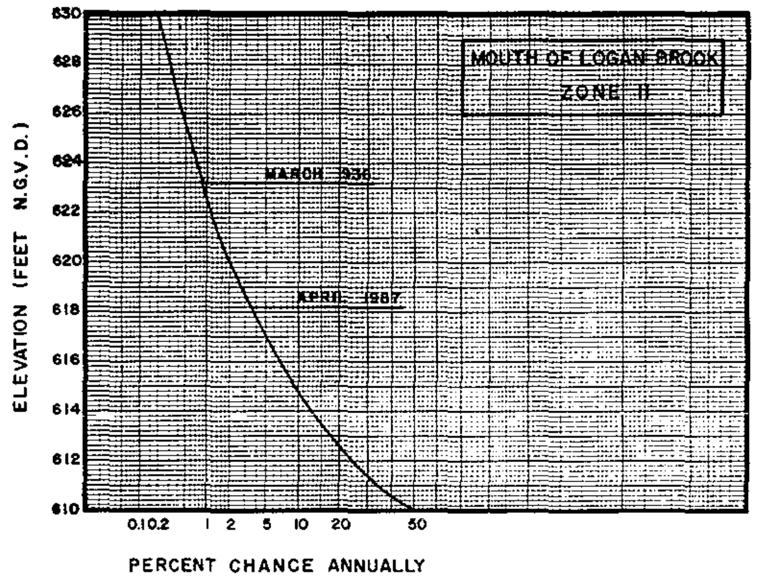
HES JAN. 1989

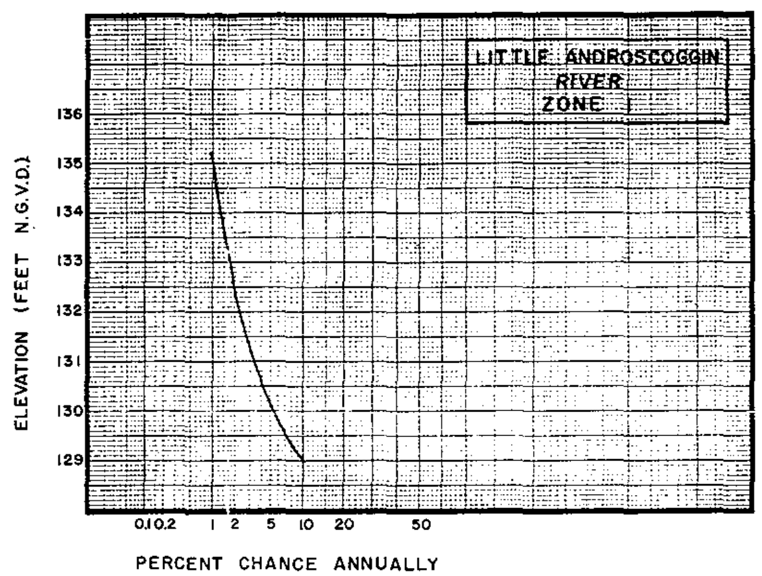
PLATE 5B

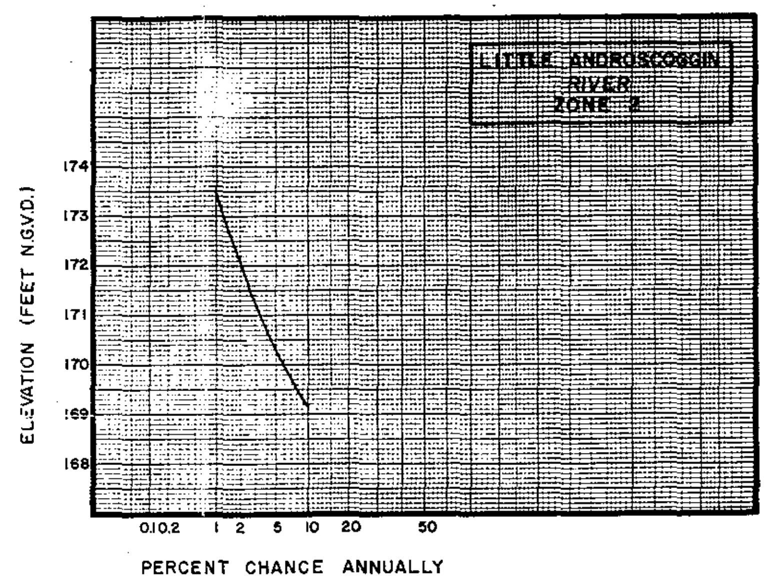


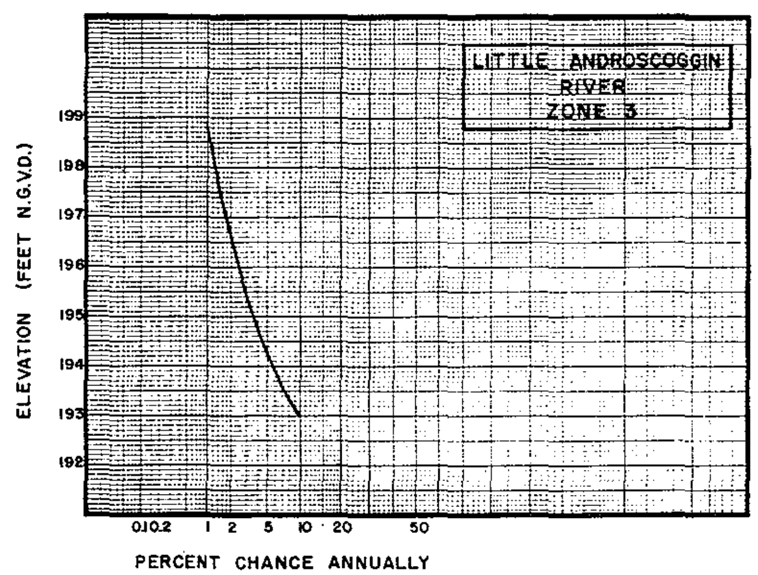



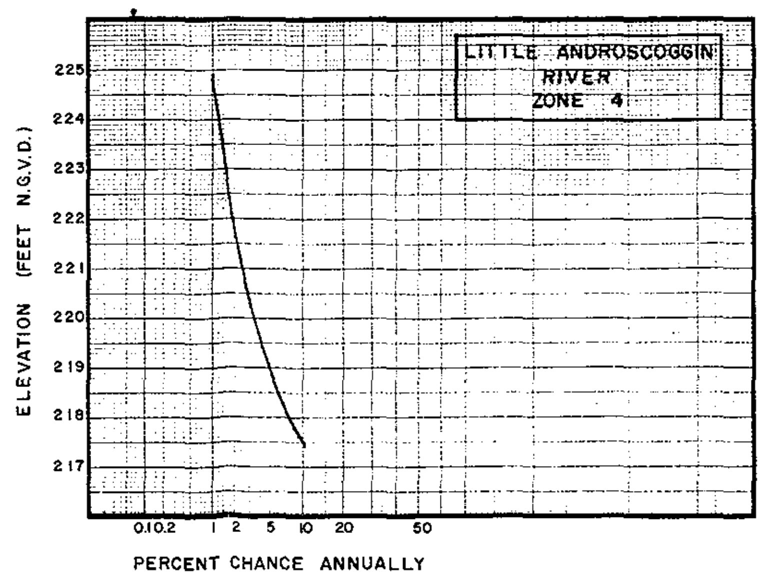

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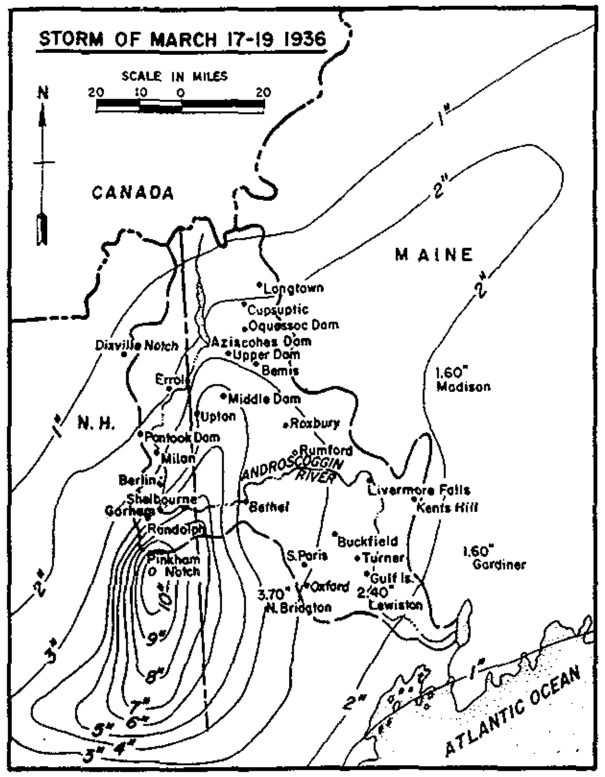
STAGE FREQUENCY CURVES

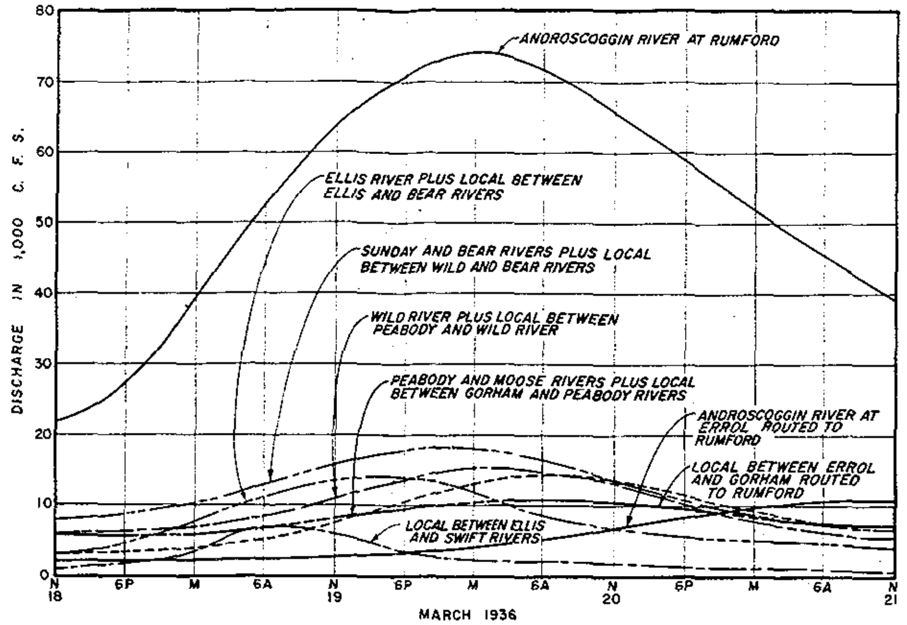
ANDROSCOGGIN AND LITTLE ANDROSCOGGIN RIVERS

HES JAN. 1989

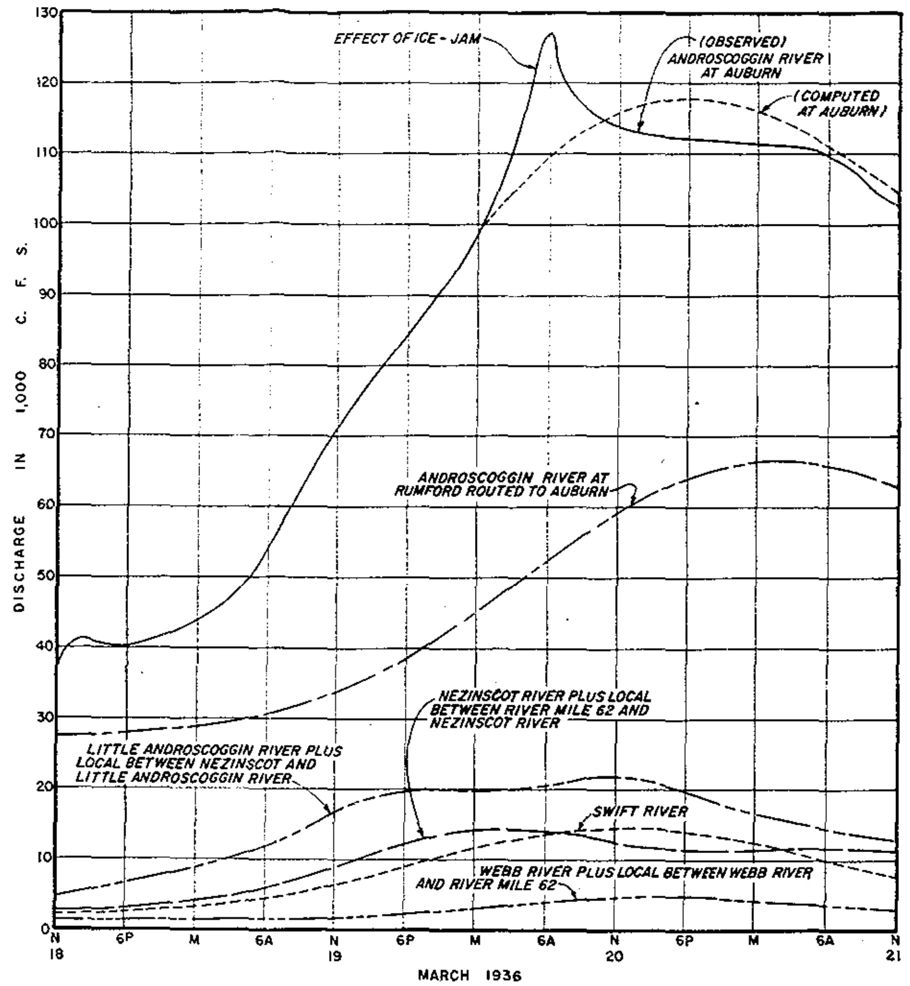
PLATE 5C




ISOHYETAL MAP




ANDROSCOGGIN RIVER AT RUMFORD




ANDROSCOGGIN RIVER AT AUBURN

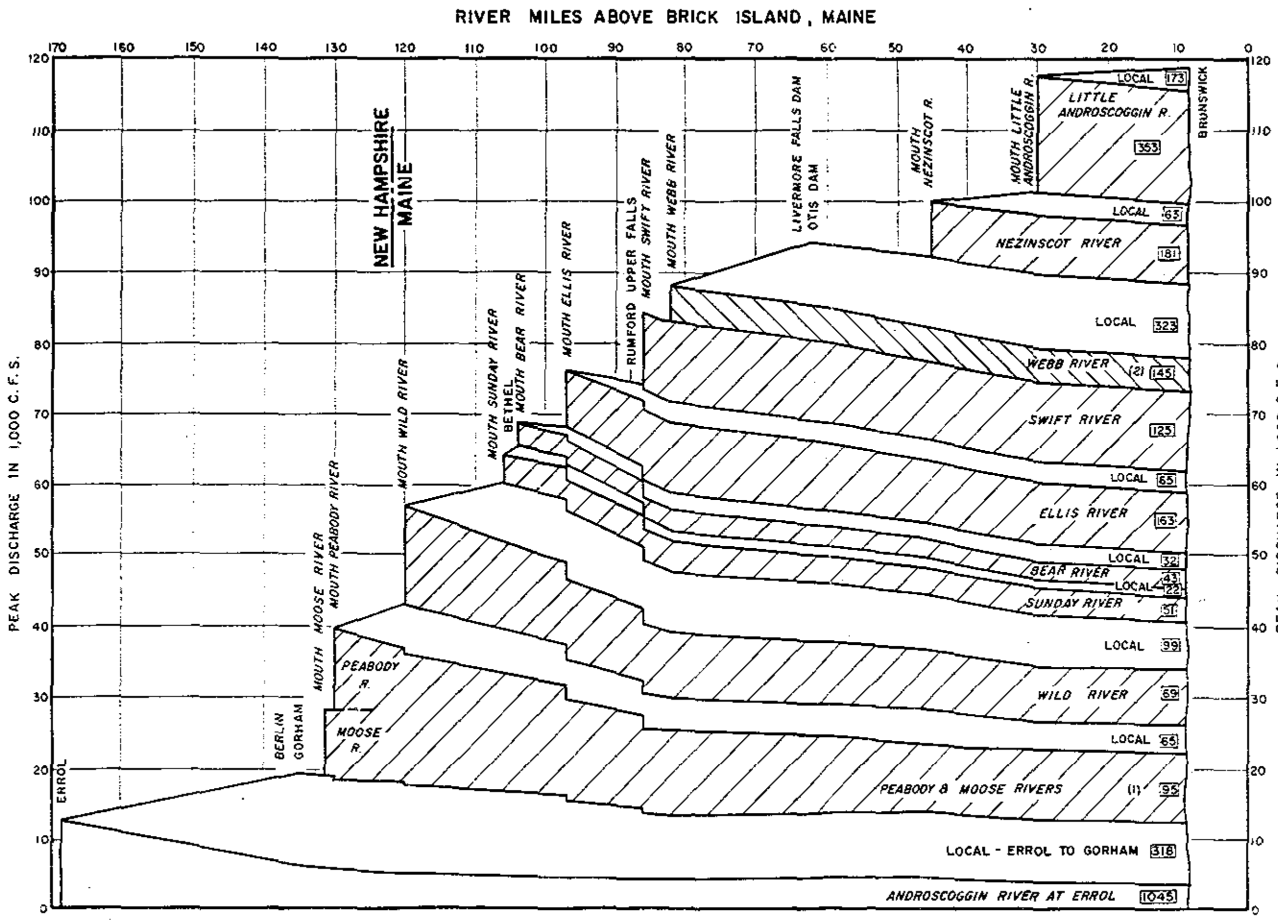
NOTES:

(1) Includes 24 sq. mi. of Local Area.

(2) Includes 13 sq. mi. of Local Area.

LEGEND

1363 Drainage Area in sq. mi.




PEAK DISCHARGE PROFILE AND TRIBUTARY CONTRIBUTIONS

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY | TR. BY M.W.B. | CK. BY

PROJECT ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANN. & RPTS. BRANCH

ANDROSCOGGIN RIVER FLOOD CONTROL

FLOOD OF MARCH 1936

ANDROSCOGGIN RIVER MAINE & N.H.

APPROVED DATE

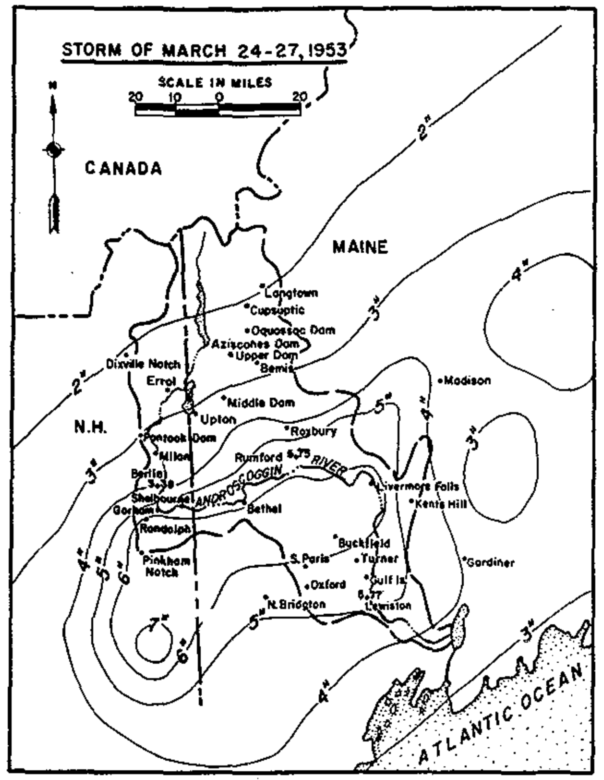
CHIEF ENGINEERING DIV.

SCALE | SPEC. NO. CIV. ENG.-19-016-

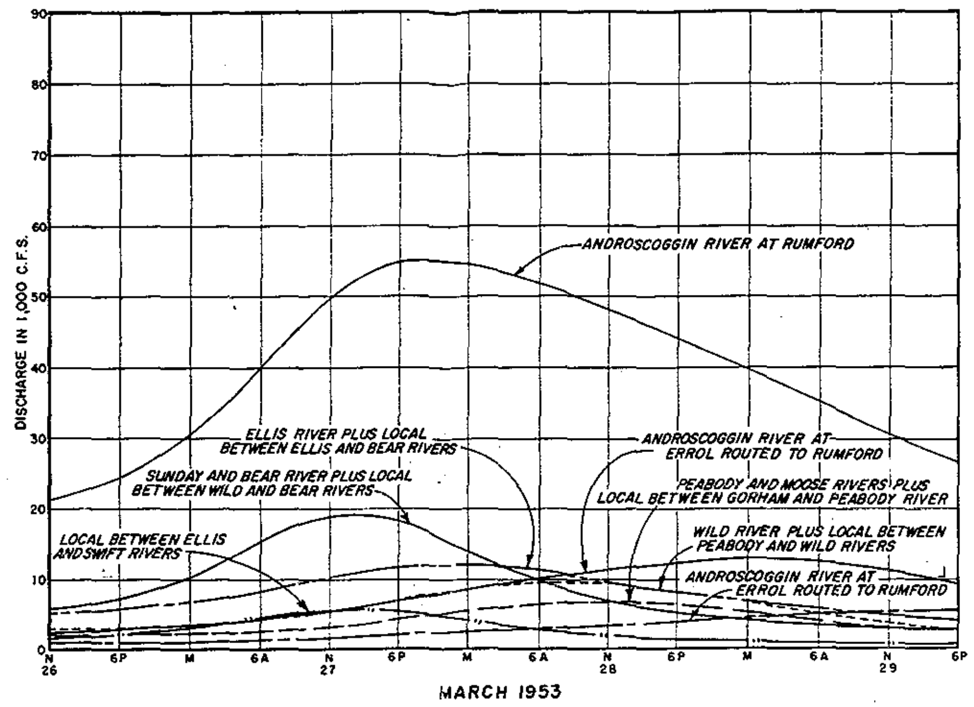
DRAWING NUMBER

SHEET

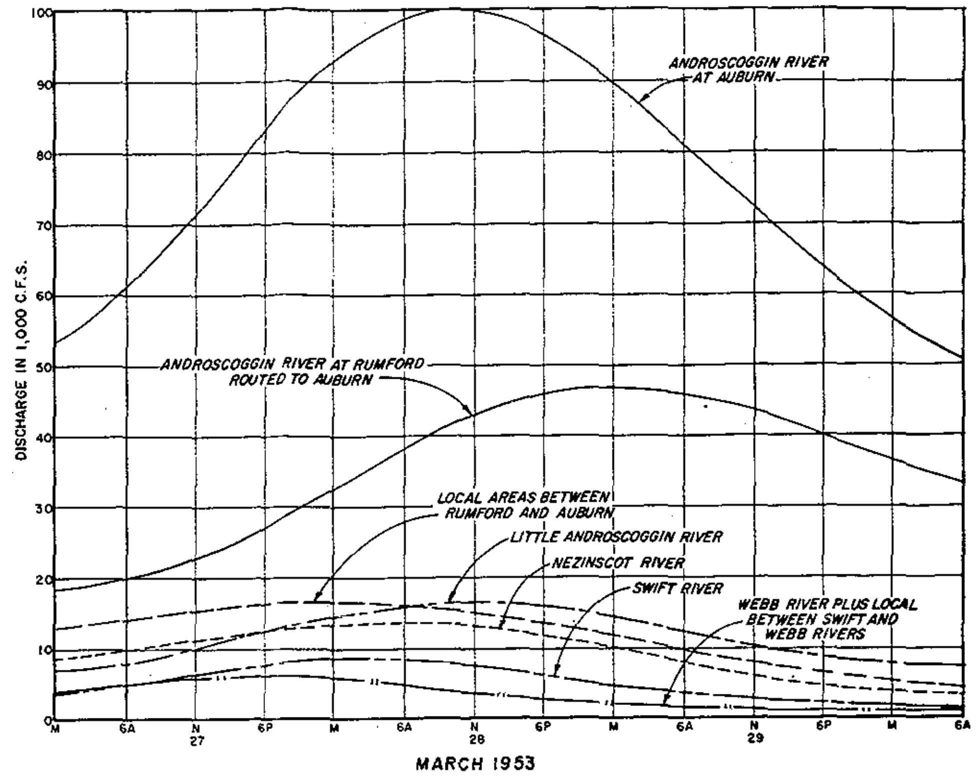
PLATE 6



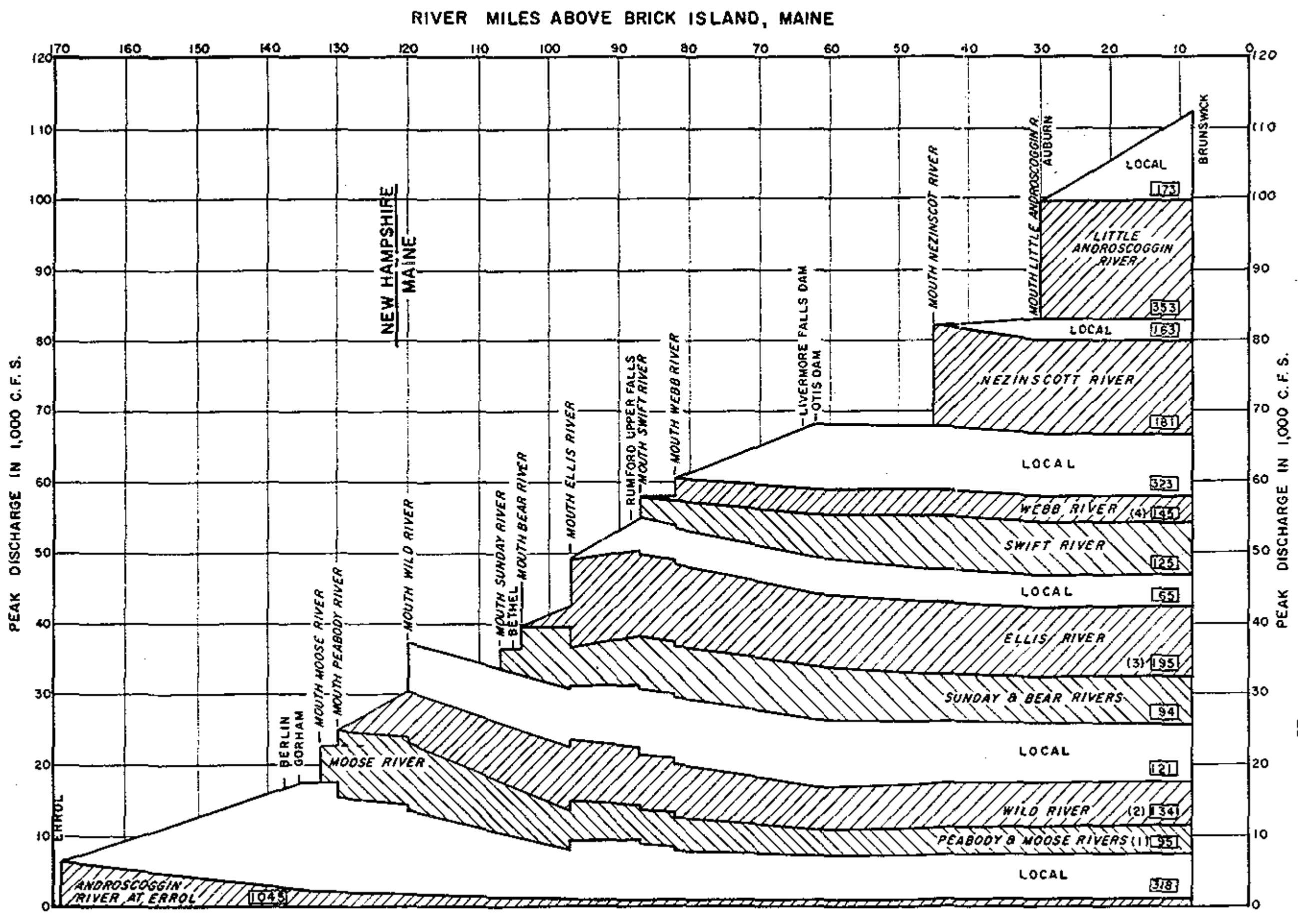

ISOHYETAL MAP




ANDROSCOGGIN RIVER AT RUMFORD




ANDROSCOGGIN RIVER AT AUBURN




PEAK DISCHARGE PROFILE AND TRIBUTARY CONTRIBUTION

LEGEND

1363 DRAINAGE AREA IN SQUARE MILES

NOTES:

(1) Includes 24 Square Miles of Local Area.
(2) Includes 65 Square Miles of Local Area.
(3) Includes 32 Square Miles of Local Area.
(4) Includes 13 Square Miles of Local Area.

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY | TR. BY G.H.D. | CK. BY

PROJECT ENGINEER

ANDROSCOGGIN RIVER FLOOD CONTROL

FLOOD OF MARCH 1953

ANDROSCOGGIN RIVER MAINE & N.H.

CHIEF SECTION
SUBMITTED BY | APPROVED | DATE

CHIEF, PLAN'G & P'T'S BRANCH | CHIEF ENGINEERING DIV.

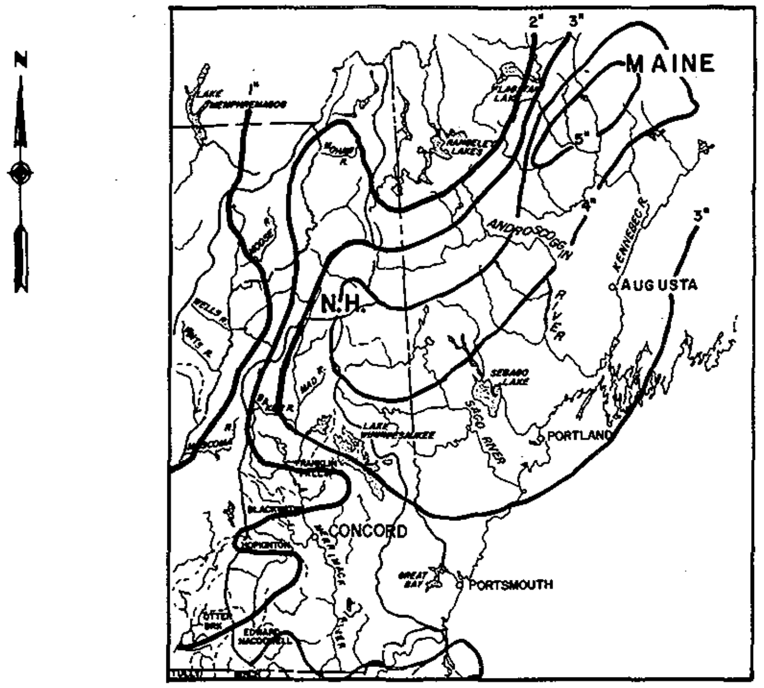
SCALE | SPEC. NO. CIV. ENG.-15-016-

DRAWING NUMBER

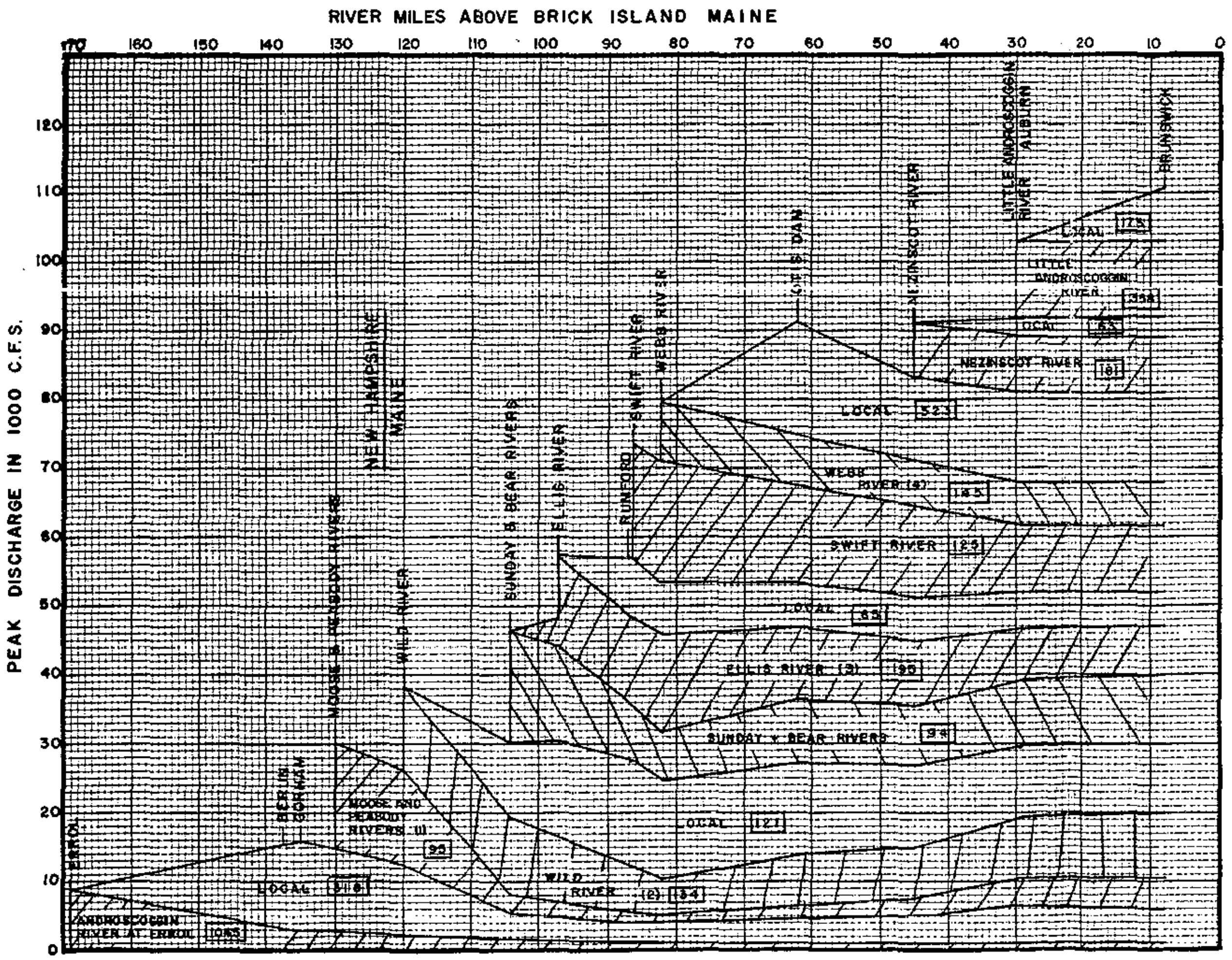
SHEET

PLATE 7

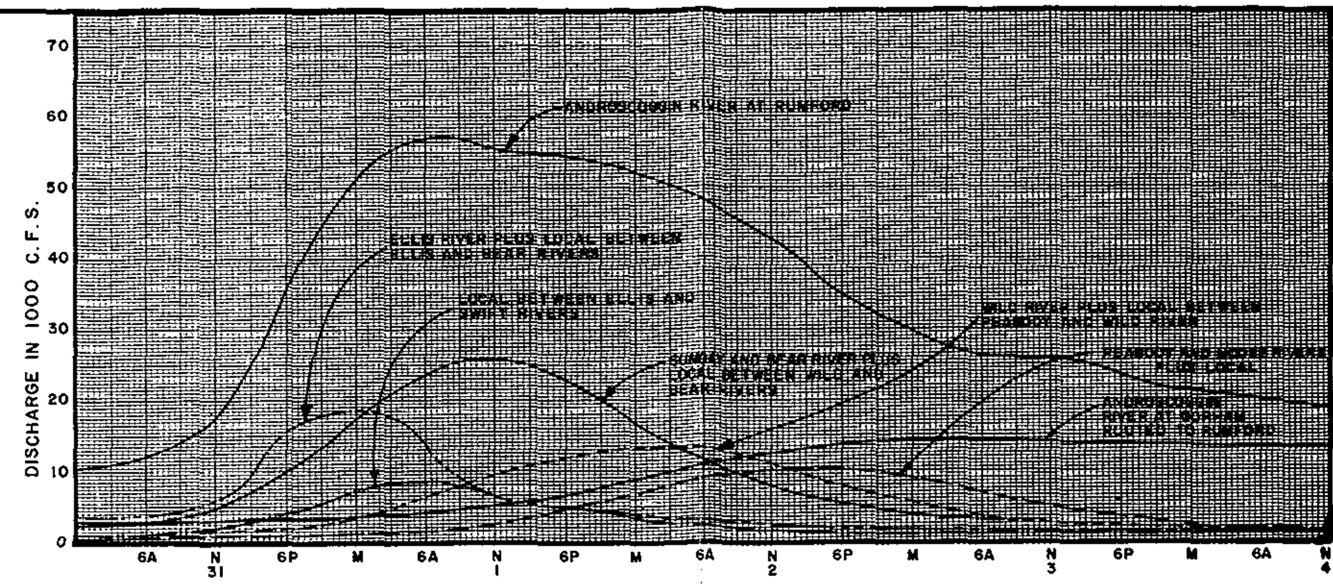
STORM OF 31 MARCH - 1 APRIL 1987



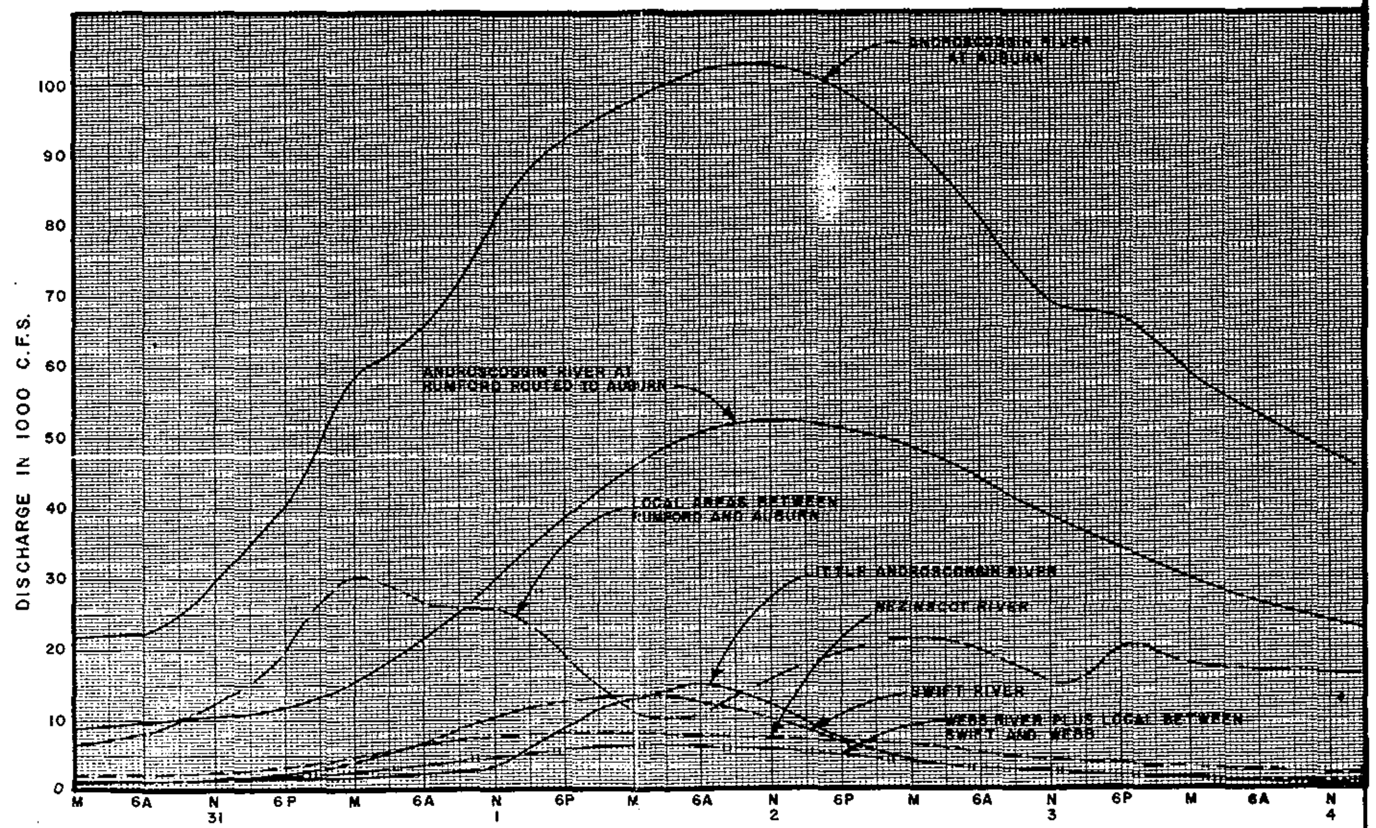

ISOHYETAL MAP




PEAK DISCHARGE PROFILE AND TRIBUTARY CONTRIBUTIONS




ANDROSCOGGIN RIVER AT RUMFORD




ANDROSCOGGIN RIVER AT AUBURN

LEGEND

[121] DRAINAGE AREA IN SQ. MI.

NOTES:

(1) INCLUDES 24 SQ. MI. OF LOCAL AREA

(2) " 65 " " " " "

(3) " 32 " " " " "

(4) INCLUDES 13 SQ. MI. OF LOCAL AREA

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WALTHAM, MASS.

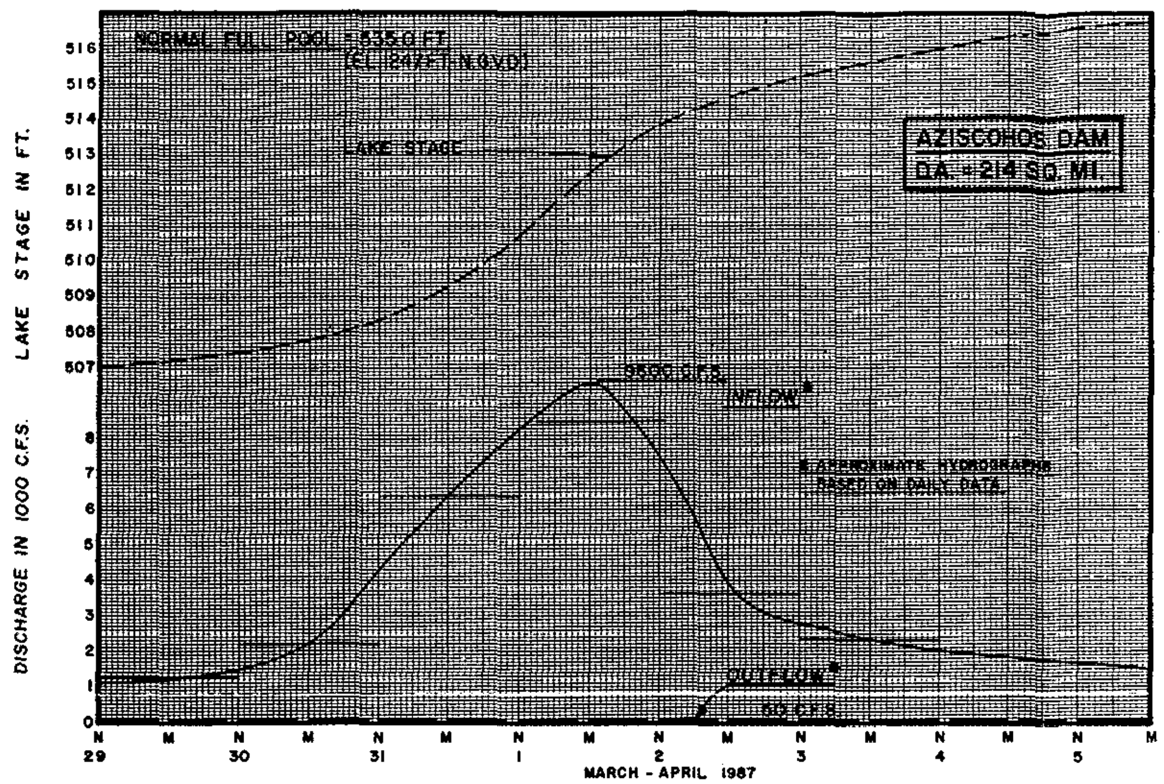
ANDROSCOGGIN RIVER BASIN

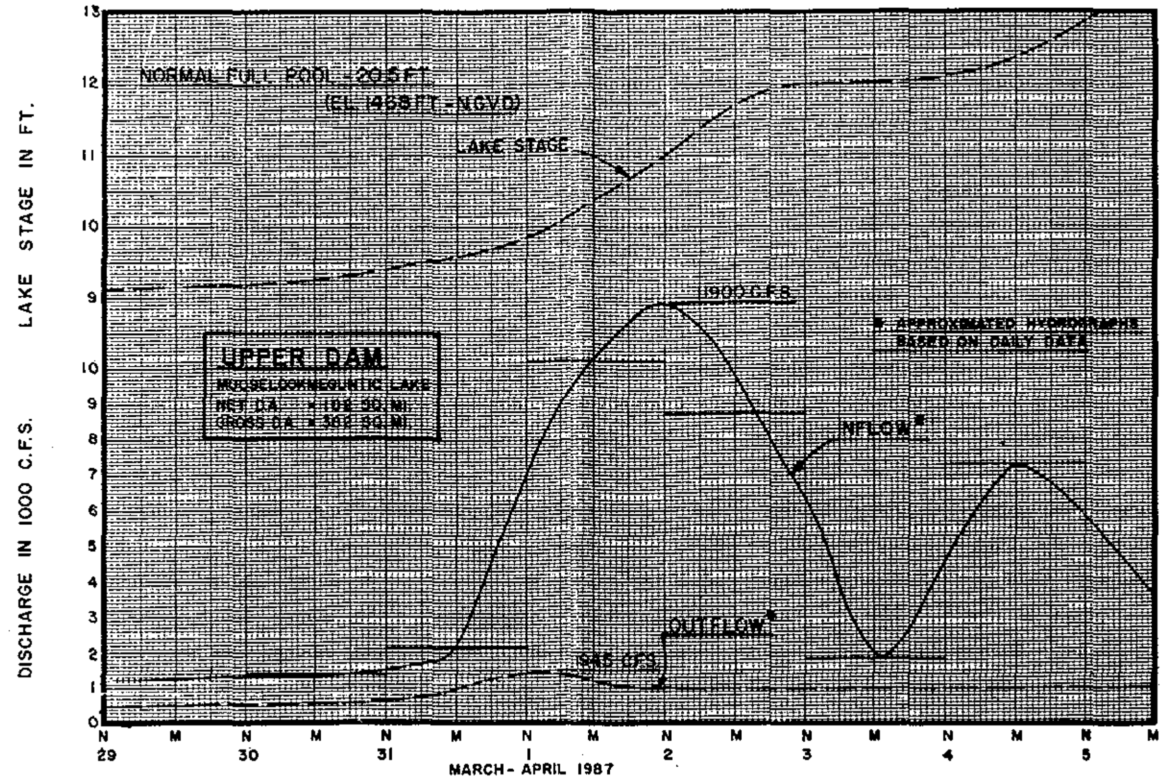
FLOOD OF

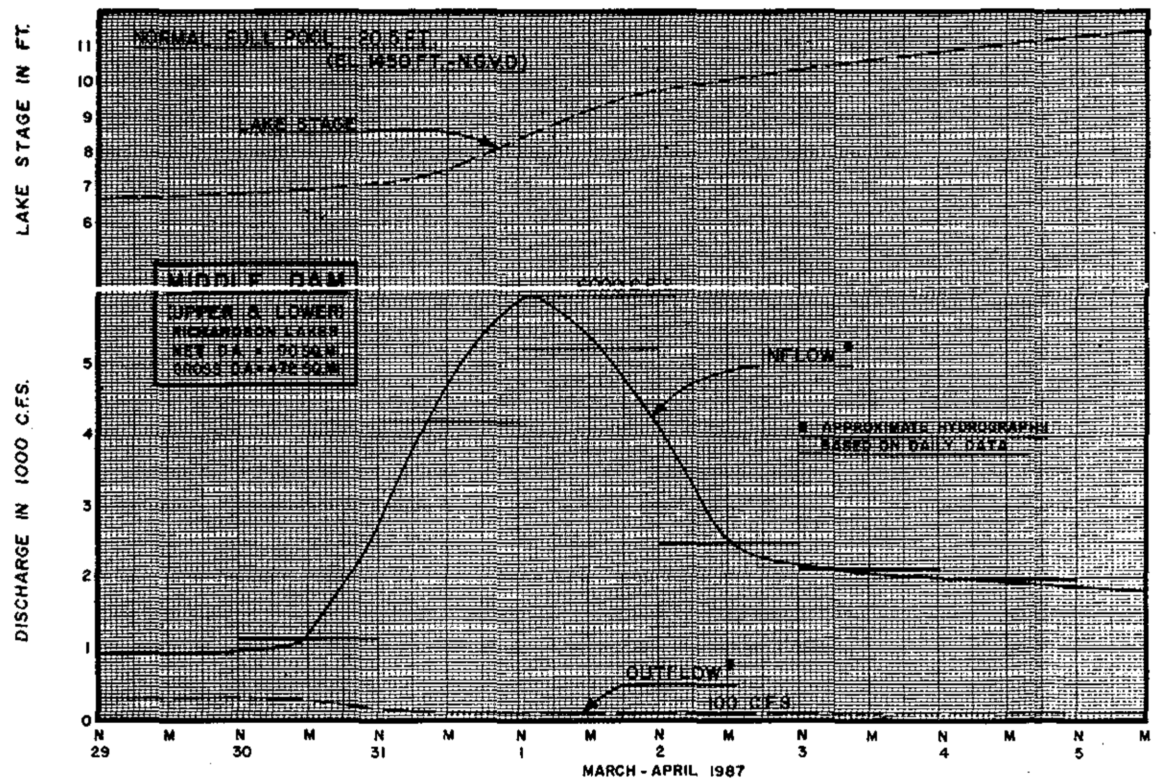
MARCH - APRIL 1987

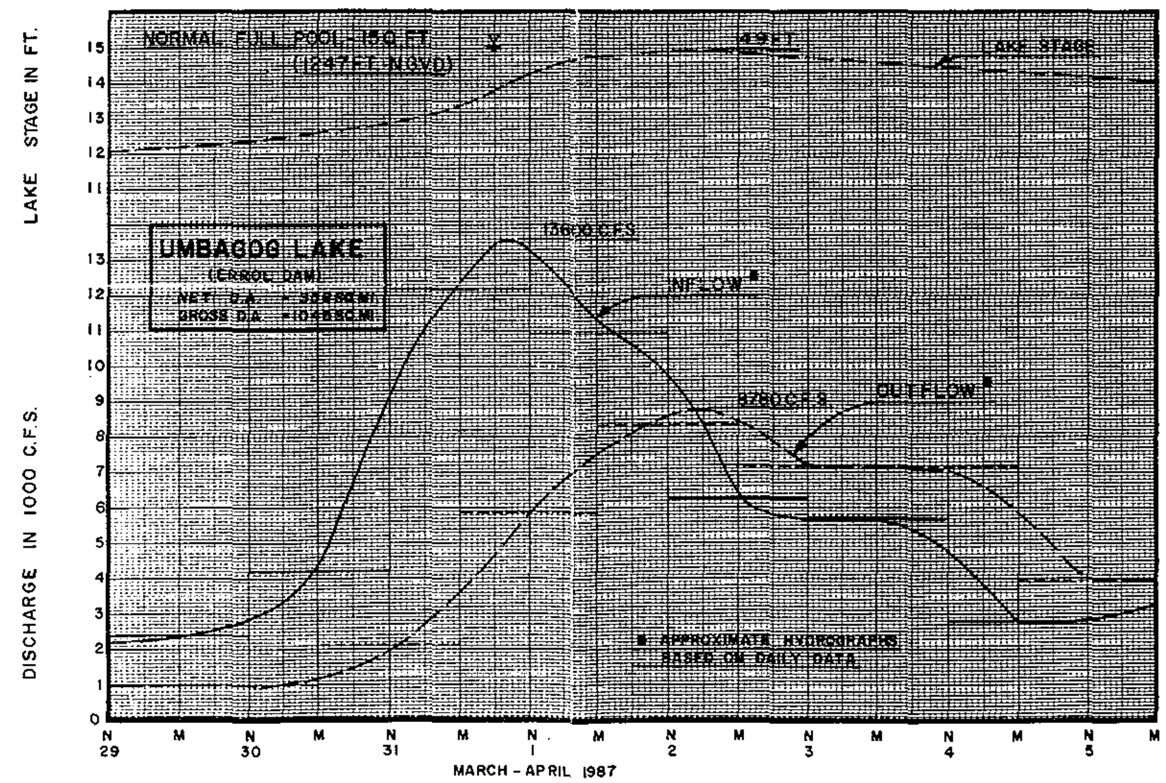
ANDROSCOGGIN RIVER | MAINE & N.H.

PLATE 8

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WALTHAM, MASS.

ANDROSCOGGIN RIVER BASIN — N.H. AND MAINE

MARCH-APRIL 1987 FLOOD ANALYSIS

UPPER BASIN STORAGE

HES — FEB. 1989

PLATE 9

ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

APPENDIX C

ENVIRONMENTAL

ANDROSCOGGIN RIVER BASIN
WATER RESOURCES STUDY
APPENDIX D

TABLE OF CONTENTS

## A. Environmental Setting

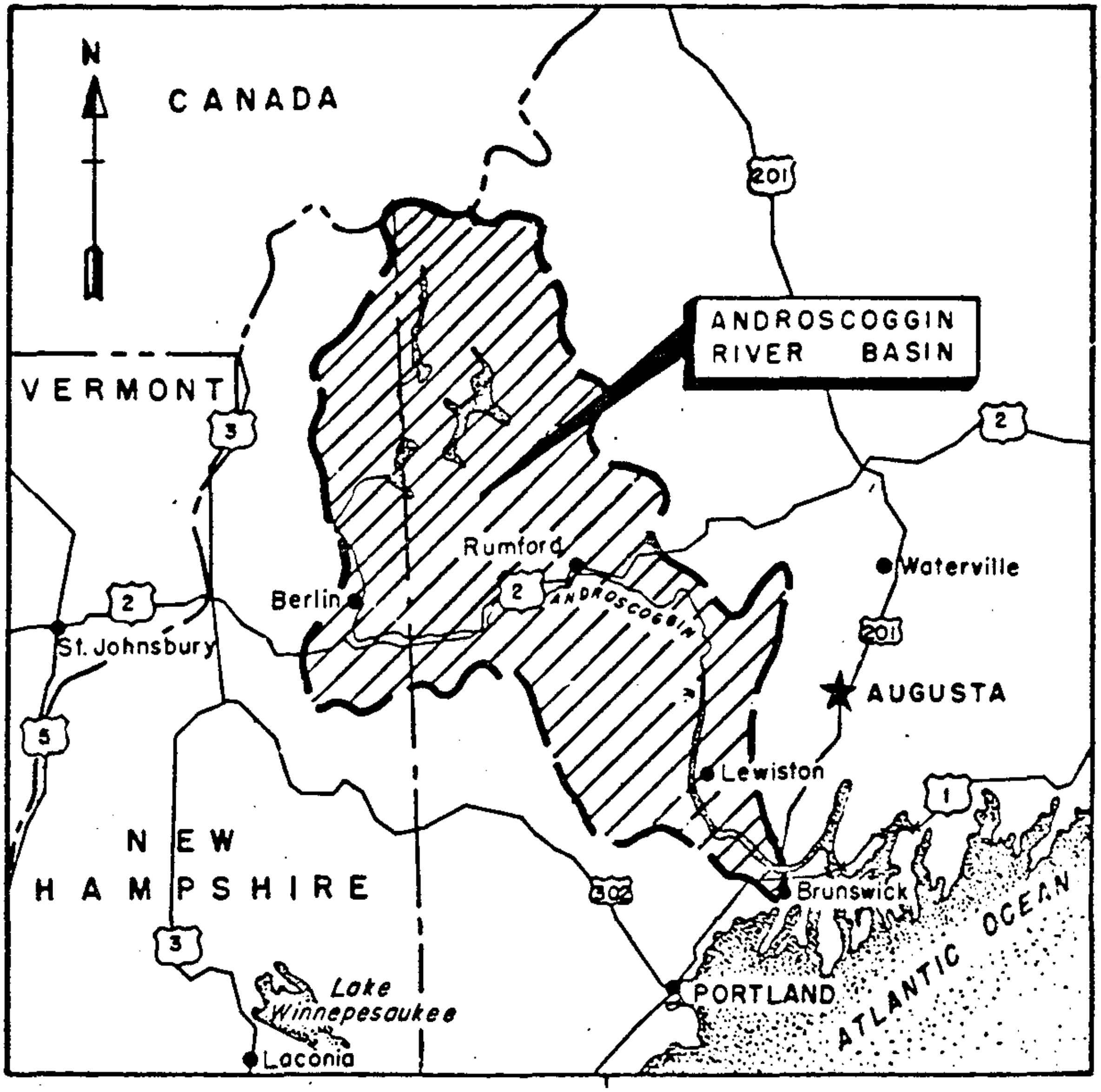
### 1. General

The Androscoggin River Basin spans approximately 3,500 square miles in western Maine and northeastern New Hampshire from the border of Canada to tidally influenced Merrymeeting Bay (Figure 1). The mainstem Androscoggin River is 169 miles long from its source at Umbagog Lake in Errol, New Hampshire to its mouth at Merrymeeting Bay, descending a total of 1,245 feet in the 161 miles above tidewater. It has two steep drops, 240 feet in 2.5 miles in Berlin, New Hampshire and 180 feet in 1.6 miles in Rumford, Maine (USAE 1967). Elevations in the basin range from the 6288-foot Mount Washington in the headwaters to sea level at Brunswick where the river becomes tidally influenced (US Fish and Wildlife Service Planning Aid Letter, Appendix A, Hereafter cited as PAL). From Umbagog Lake the river flows generally southerly to Gorham, New Hampshire where it turns to flow easterly toward Livermore Falls. From Livermore Falls it again flows southerly to Merrymeeting Bay and the Atlantic Ocean.

The Androscoggin River Basin is best described in terms of an upper and lower basin. The upper basin above Rumford is forested and mountainous and contains a number of reservoirs constructed for log driving during the 19th century (UWPC) and now used for hydropower production. The basin below Rumford is less mountainous and contains more lakes and ponds and agricultural land.

Flows in the Androscoggin River are regulated from the Rangeley Lakes, a series of modified natural lakes in the headwaters. The Rangeley Lakes include: Kennebago Lake, Rangeley Lake, Mooselookmeguntic Lake, Upper and Lower Richardson Lakes, Aziscohos Lake, and Umbagog Lake. Most notable of these lakes are Aziscohos Lake, Umbagog Lake, Upper and Lower Richardson Lake, and Rangeley Lake. These lakes are considered in this study for reregulation to control downstream flooding. Storage capacity of the lakes has been increased by outlet control structures. The reservoirs are owned and operated by the Union Water Power Company (UWP), a subsidiary of Central Maine Power Company (CMP) and the Androscoggin Reservoir Company (ARCo), comprised of several downstream water users, including CMP. There is currently hydropower generation at Aziscohos Dam and Errol Dam and there is a pending Federal Energy Regulatory Commission (FERC) proceeding to license Middle Dam as a storage project. Fish and wildlife mitigation measures are currently being developed at Middle, Aziscohos, and Errol dams under the statutory requirements of the FERC licensing process (PAL).

Hydropower operation of the Rangeley Lakes involves capturing spring runoff to be released over the remainder of the year to provide for downstream water users. Flow releases are in accordance with an agreement between the owners of the storage




LOCATION MAP

SCALE IN MILES

10 0 10 20 30 40 50

Figure 1

reservoirs and downstream water users that has been in effect since 1909. Although storage releases augment natural flows in the river, this does not necessarily result in fishery habitat enhancement, as demonstrated by in stream flow studies recently completed at the Pontook Hydropower Project (PAL).

The Androscoggin River flows through many run-of-river hydropower projects at and below Berlin, N.H. Appreciable storage in the system occurs at Gulf Island Dam (FERC No. 2283), located just upstream of Auburn, Maine. Gulf Island Pond serves as a re-regulation reservoir for a number of downstream hydropower projects. It is operated in a weekly cycling mode with reservoir refill on the weekends. Studies to assess fish and wildlife impacts and develop mitigation measures are currently underway as part of the FERC relicensing process for Gulf Island Dam (PAL).

A number of tributary streams flow into the Androscoggin River over its length. The tributaries of greatest importance to this reconnaissance study from upstream to downstream are Ellis River, Swift River, Webb River, Dead River, Nezinscot River, Little Androscoggin River, and Sabbatus River. These are potential locations of flood control structures considered for reregulation to control downstream flooding.

2. Topography and Geology

The Upper Androscoggin Basin lies mostly within the White Mountain Section of the New England Physiographic Province. The mountainous terrain is broken by several relatively wide stream valleys and, locally, there are large basins occupied by great lakes such as the Rangeleys and others that are connected to discharge to the Androscoggin.

Prior to glaciation, the topography was in a mature stage of erosion with a network of sharply incised stream valleys having graded profiles. Lakes and swamps did not exist and the overburden was the product of weathering of the bedrock. Glaciation modified this topography by erosion and deposition and disrupted the drainage system. There are evidences that the present circuitous, south and easterly course of the Androscoggin River is altered from a pre-glacial drainage westward to the Connecticut River Valley.

Glacial till, a mass mixture of soil and rock debris of all sizes scraped up and transported by the ice, variably blankets the bedrock surface throughout most of the Upper Basin. The till is thin or absent at high elevations and of considerable thicknesses on lower hill slopes and in the valley sections. Overlying the till in the valleys and in local basins are sorted deposits of glacial materials that were outwashed from the ice by meltwaters and deposited as sand and gravel terraces and plains.

The bedrocks of the basin, except for an area of relatively young slates and volcanics near the Rangeley Lakes, are very old sediments that have been metamorphosed to schist, gneiss and quartzite. These rocks have been much folded to a general northeasterly trend of structure and are frequently cut by igneous intrusions of a mainly granitic composition.

The pegmatites (coarse-grained granites) of the basin are a source of marketable minerals, principally feldspar, mica, and beryl with subordinate occurrences of rare minerals and minerals of gem quality. Principal production has been from the Rumford-Newry area at several intermittently operated mines and quarries.

3. Water Quality

Waters of the Upper Drainage of the Androscoggin River (that portion within the State of Maine lying above the rivers' most upstream crossing of the Maine-New Hampshire boundary) and tributary streams are Class A except for Rapid River which is rated Class B (Maine DEP 1987).

Umbagog Lake and the Androscoggin River up to Berlin, New Hampshire are Class B. The portion of the Androscoggin River from Berlin to the Maine-New Hampshire border is Class C. Horn Brooks and Bean Brook are Class A at their headwaters with the remainder Class B (NH DES 1988).

The state of Maine classifies the main stem Androscoggin River, including all impoundments, from the Maine-New Hampshire boundary to a line formed by the extension of the Bath-Brunswick boundary across Merrymeeting Bay as Class C. At certain times portions of the waters in the impoundments created by Gulf Island, Deer Rips, and Lewiston Falls Dams do not meet the Class C requirements for aquatic life and dissolved oxygen. Because of the value of hydropower energy to the state these impoundments are considered to meet their classification if the DEP finds that conditions in these impoundments are not preventing their designated uses from being reasonably attained.

The Little Androscoggin River is alternately classified B and Class C along its length. All of its major tributaries are Class C.

A description of the standards for classification of fresh surface waters is provided in Appendix B (Maine DEP 1987).

## 4. Aquatic Resources

### a. General

The Maine Department of Inland Fisheries and Wildlife (MDIFW 1985) has divided the state into seven Fisheries Management Regions. The Androscoggin River Basin is located within the Rangeley (D), Sebago (A), and Belgrade (B) Regions (Figure 2). Fisheries within the basin change a great deal from north to south. The upper basin supports mostly naturally reproducing salmonids while the more southern reaches support mostly put and take salmonids and warm water fisheries.

Seven reservoirs in addition to a number of other run of the river storage facilities are being considered for re-regulation. One of these is located entirely in New Hampshire, Pontook Reservoir, and one, Umbagog Lake, is located on the New Hampshire-Maine border. The remaining lakes, Aziscohos, Mooselookmeguntic, Rangeley, Upper and Lower Richardson, and Gulf Island are located in Maine. Five of the lakes, Kennebago, Rangeley, Upper and Lower Richardson, Mooselookmeguntic, and Aziscohos are part of the Rangeley Lakes which is one of the most important fishing regions of inland Maine (Cooper 1940). These lakes support similar species of fish with naturally reproducing populations of brook trout (Salvelinus fontinalis) and landlocked salmon (Salmo sebago) sharing the greatest importance. Kennebago, Rangeley, and Mooselookmeguntic have the best fisheries for these species, due to the availability of excellent spawning tributaries and the relatively small water level fluctuations. Richardson Lakes offer a high quality fishery also, however growth rates for salmon are somewhat lower (PAL).

A general list of fish species of the Rangeley Lakes is shown on Table 1. Brown trout have also been introduced and are rare (PAL). Umbagog Lake supports a warm water fishery as well, which includes chain pickerel (Esox niger), horned pout (Ameiurus nebulasussp), yellow perch (Perca flavescens), and whitefish (Coregonus) (NHFG 1972). The three major fish species which reproduce naturally in the Androscoggin River Basin are landlocked salmon, brook trout, and smallmouth bass. Brief descriptions of their spawning habits from "Planning for Maine's Inland Fish and Wildlife", Volume II, Part 1 prepared by the Maine Department of Inland Fisheries and Wildlife (1985) follow. The potential to impact fish through water level manipulation is greatest during spawning.

Landlocked salmon spawn in the fall in lake inlets or outlets. The young hatch in early spring and remain in stream "nursery" areas 1 or 2 years before moving into lake habitat, where they soon begin to feed on fish, primarily smelts, and grow much more rapidly. Salmon in most Maine lakes reach legal size (14 inches) in their third, fourth, or fifth year of life.

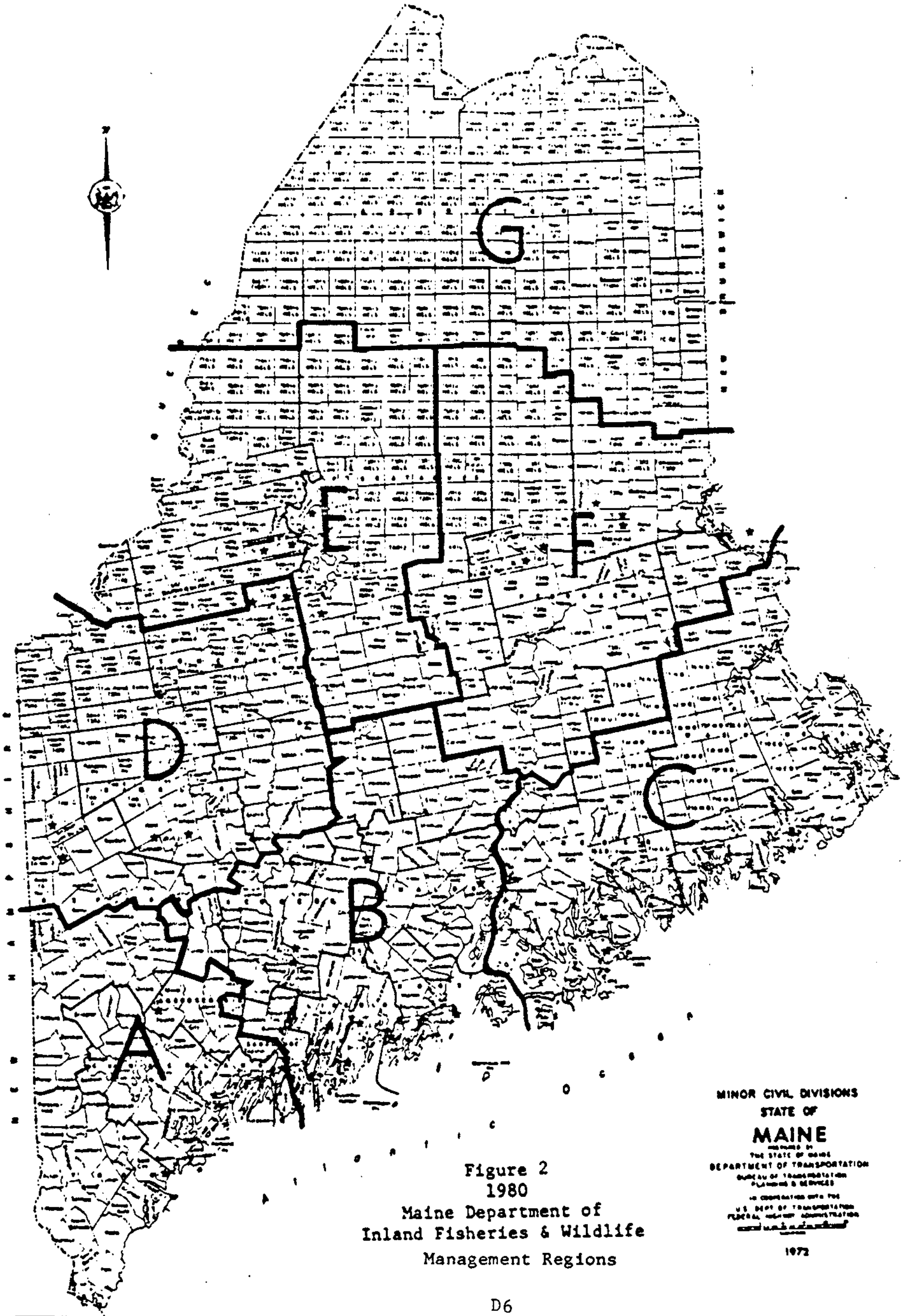



Figure 2
1980
Maine Department of
Inland Fisheries & Wildlife
Management Regions

**TABLE 1** The distribution of different species of fishes in the Rangeley lakes and their tributaries, as determined from seine collections made by the present survey. An X indicates that the species was found to be present

| Kind of fish | | Lake and tributaries | | | | Lake and tributaries | | | | | Lake and tributaries | | | | Lake and tributaries | | | | Lake and tributaries | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lower Richardson Lake | Upper Richardson Lake | Metalluck Bk. | Mosquito Bk. | Beaver Bk. | Mooselookmeguntic and Cupsuptic lakes | Bemis Stream | Cupsuptic R. | Toothaker Bk., trib. of Cupsuptic R. | Kennebago R. | Rangeley Lake | South Bog Stream | Dodge Pond Stream | Long Pond Stream | Kennebago Lake | Wilbur Br. | Bug Sag Bk. | Little Kennebago R. | Aziscoos Lake | Little Magalloway R. | Magalloway R. |
| Smelt<br>*Osmerus mordax* | X | X | | | | X | | | | | X | | | | | | | | X | | |
| Land-locked Salmon<br>*Salmo sebago* | | | X | | | | | | | X | X | | X | | | | | X | | | |
| Brook Trout<br>*Salvelinus f. fontinalis* | | | X | X | | | X | X | X | X | | X | | X | | X | X | X | | | |
| Common Sucker<br>*Catostomus c. commersonnii* | X | X | | | X | X | | | | X | X | X | X | | | | | | | X | X |
| Fine-scaled Sucker<br>*Catostomus c. catostomus* | | | | | | | | | | | X | X | | | | | | | | | |
| Lake Chub<br>*Couesius plumbeus* | X | X | | | | | | | | | X | X | X | | X | | | X | X | | X |
| Black-nosed Dace<br>*Rhinichthys a. atratulus* | | | | | | | | X | | X | X | X | X | | X | | X | X | X | X | X |
| Fallfish<br>*Leucosomus corporalis* | X | X | X | | X | | X | | | X | X | | X | | | | | | X | | X |
| Creek Chub<br>*Semotilus a. atromaculatus* | | | | | X | | | | | X | | | X | | | | | | | X | |
| Northern Dace<br>*Margariscus m. nachtriebi* | X | X | | | | X | | | | | | | | | | | | | | | |
| Fine-scaled Dace<br>*Pfrille neogaea* | | X | | | X | | | | | | | | | | | | | | | | |
| Red-bellied Dace<br>*Chrosomus eos* | | X | | | X | X | | | | | | | X | | | | | | X | X | X |
| Black-nosed Shiner<br>*Notropis h. heterolepis* | | | | | | | | | | | X | | X | | | | | | | | |
| Common Shiner<br>*Notropis c. cornutus* | | X | | | X | | | | | X | X | X | X | | | | | | | | |
| Fat-headed Minnow<br>*Pimephales p. promelas* | X | X | | | | X | | | | | | | | | | | | | | | |
| Bullhead or Horned Pout<br>*Ameiurus n. nebulosus* | | X | | | X | | | | | | | | | | | | | | | | |
| Fresh-water Sculpin<br>*Cottus cognatus* | | | | | | | | | | | | X | | | | | | | | X | |

From: "A Biological Survey of the Rangeley Lakes, with Special Reference to the Trout and Salmon" by Gerald P. Cooper 1940.

Brook trout normally spawn in the flowing waters of brooks or streams; the act occurring in the fall (usually October to November). However, shore spawning occurs commonly in some ponds under certain conditions. The presence of springs and ground water inflows appears to be the over-riding factor which determines occurrence of shore spawning. Success of shore spawning is highly variable among different ponds.

The brook trout's basic habitat requirements are cool, well-oxygenated water and suitable spawning sites. As long as water temperatures do not exceed about 68oF. for long periods and oxygen values remain about 5 p.p.m., the brook trout can usually survive and grow. A brook trout may spend any part or all of its life in habitats ranging from the smallest brook to the largest of lakes. In addition, they are capable of spending portions of their lives in marine or brackish waters; although they cannot spawn there.

Smallmouth bass thrive in lakes and ponds with clean,fertile water. Suitable shoreline spawning gravel and stable water levels are also important. Smallmouth bass spawn in the late spring and early summer.

Rainbow smelt are the primary forage species. They spawn in the spring (end of April) for 2-4 weeks in tributaries but not far from the lake (R. Desandre, pers. comm. 22 Dec 1988).

b. Lake Descriptions

Umbagog Lake

Umbagog Lake is a natural lake with a water level raised by damming. Its area is 7,850 acres, 4,532 acres of which lie in New Hampshire. Its maximum depth is approximately 48 feet in the vicinity of the Rapid River inlet in Maine. The bottom is a mixture of mud, rock and sand and the shoreline consists of sand, gravel and cobble. Submergent vegetation was described as common from a survey by the New Hampshire Fish and Game (New Hampshire Fish and Game 1972). The shallow portions of the lake provide a warm water fishery and the northeastern embayment in Maine provides a cold water fishery. Most of the lake shoreline appears to be upland dominated by forest species typical of the area: balsam fir, white pine, and white birch. Portions of the shoreline support pockets of forested and shrub wetlands dominated by deciduous trees and shrubs and in some areas a fringe of emergent sedge wetland is present.

Aziscohos Lake

Aziscohos Lake is the only entirely artificial reservoir of the Rangeley Lakes. It was created by damming the Magalloway River at Wilson's Mills. It is approximately 6,700 acres in area with a maximum depth of approximately 50 feet. The shoreline of Black Brook Cove, observed during the November 1988 site visit, was composed of cobbles. Shoreline vegetation was dominated by red spruce and white pine. The water level was down about seven feet during the site visit and growth of sedges along the exposed cobble shoreline suggests that the low water level is maintained over a long duration.

Aziscohos Lake has the poorest cold water reservoir fishery relative to the other upper lakes. This is due to extreme water level fluctuations and to poor water quality in the summer months which results from stratification and low dissolved oxygen levels. Salmonids move out of the Aziscohos Lake and into the Magalloway River and other tributaries during the late summer months to seek refuge from stressful water quality conditions (PAL).

<u>Richardson Lakes</u>

Upper and Lower Richardson Lakes make up approximately 2,900 and 4,200 acres respectively. The maximum depth of these lakes is approximately 100 feet (Cooper 1940). The water level at the Mill Brook inlet was down approximately five feet during the November 1988 site visit. The exposed shoreline spanned as much as 60 lateral feet and was composed of boulders and gravel grading into sand toward the water. Surrounding upland vegetation consisted of red spruce, white pine, and birch.

Lake trout have been introduced into Richardson Lakes by the Maine Department of Inland Fisheries and Wildlife. There is no evidence of successful reproduction (DeSandre, pers. comm. Dec. 1988). This is presently not considered to be a problem as it allows the State to carefully manage the species by stocking without risk of excessive competition with native salmonids (PAL).

<u>Mooselookmeguntic Lake</u>

Mooselookmeguntic Lake and Cupsuptic Lake, together, are the largest of the Rangeley Lakes at 16,300 acres. Cupsuptic Lake is essentially the northernmost bay of Mooselookmeguntic Lake separated from the remainder of the lake by a shallow area near the Kennebago River and Rangeley Stream inlets. The maximum depth of these lakes is approximately 130 feet (Cooper 1940). Mooselookmeguntic Lake, along with Kennebago Lake and Rangeley Lake, has the best brook trout and landlocked salmon fishery of the Rangeley Lakes (PAL).

The water level at Mooselookmeguntic Lake was low during the November 1988 site visit, exposing a grassy rim between the open water and the upland shoreline. Upland vegetation was dominated by white pine, Northern white cedar, red spruce and birch. Shrub wetlands were also present and separated from the open water.

### Rangeley Lake

Rangeley Lake is a 6,000 acre impoundment with a maximum depth of approximately 150 feet. The water level at this lake during the November 1988 site visit appeared to be near normal. Lesser water level fluctuations at this lake are credited with contributing to increased quality of the brook trout and landlocked salmon fisheries. Extensive emergent and scrub/shrub (bog) wetlands present along the Rangeley Lake shoreline are also benefited by a stable water level.

Rangeley Lake has an excellent landlocked salmon and brook trout fishery. Several landlocked salmon nests were observed at the dam by Route 4 during the site visit.

The upland shoreline and surrounding vegetation of Rangeley Lake includes Northern white cedar, hemlock, red spruce, yellow, white, gray and black birch, striped maple, aspen, and white pine.

## c. Riverine and Run of the River Habitats

The flow of the Androscoggin River is interrupted numerous times along its length by dams. Where unimpeded by dams the river's flow is rapid with few riverside wetlands. The northern sections of the river, generally above Berlin, New Hampshire, are characterized by fairly shallow rapidly flowing riffles and emergent boulders. The bordering upland habitat is dominated by coniferous forest. More southerly portions of the river are deeper and wider with steep low banks. The bordering upland vegetation here is dominated by gray birch, red maple, oaks, and white pine.

In the vicinity of dams lake-like conditions exist. Fisheries change from cold water species dominance to warm water species, which are generally considered to be of lower quality. Several dam sites were visited in the field including Pontook Dam, two dams in Gorham, New Hampshire, one dam in Shelburne, NH, two dams in Berlin, NH, one dam at Lisbon Falls, Maine, and a dam at Rumford-Mexico, Maine. The dams at Berlin and Rumford-Mexico are surrounded by dense industrial development and support little surrounding natural habitat. At sites where heavy industrial development is absent and slopes are suitable scrub-shrub and emergent wetlands often are present.

The portion of the Androscoggin River below Brunswick Dam which is open to MerryMeeting Bay appears to support more frequent riparian wetlands than other portions of the river. The entrance to the bay up to about West Chops Point is classified as Riverine by the US Fish and Wildlife Service, National Wetlands Inventory. The estuarine limits are located at the entrance and east of Chops.

### d. Major Impoundments and Mainstream Fisheries

Two major run of the river reservoirs are present on the Androscoggin River. These are the Pontook Reservoir in Dummer, New Hampshire and Gulf Island Pond in Lewiston and Auburn, Maine. Both of these rivers change the character of the affected portion of the Androscoggin River significantly. The effects of other smaller dams on the character of the river are similar but lesser.

Pontook Reservoir is a 96 acre artificial pond. It is located on the Androscoggin River and was created by a dam installed for logging purposes. Its maximum depth is 15 feet with an average depth of five feet and transparency to four feet as of a 1952 survey. The bottom was 80 percent muck and 20 percent rock (New Hampshire Fish and Game 1972). The wetlands surrounding the reservoir upstream of the dam include extensive emergent wetlands dominated by sedges and shrub/scrub wetlands dominated by alder. Submergent aquatic vegetation was described as abundant after the 1952 survey. The uplands surrounding Pontook Reservoir are dominated by white birch and white spruce.

The Pontook Reservoir is primarily a warm water fishery supporting black bass, chain pickerel, and yellow perch. Additionally the New Hampshire Department of Fish and Game stocks brook, brown, and rainbow trout annually in the vicinity of the Pontook Hydroelectric Project (PAL). There is relatively little recent information available for fisheries in the New Hampshire portion of the Androscoggin River basin but this basin as well as the rest of northern New Hampshire is receiving increasing emphasis (L. Miller pers. com. 1 Jan. 1988).

Gulf Island Pond was created by the construction of a dam on the mainstem Androscoggin River about three miles north of Lewiston-Auburn. The pond, essentially, retains its riverine linear form as does the Pontook Reservoir. Water quality is depressed in the pond compared to the surrounding riverine habitats. Because of the lesser water quality Gulf Island Pond supports a predominantly warm water fishery with only occasional trout. The major gamefish and panfish are largemouth bass, brown bullhead, pickerel, and yellow perch (D. McNeish, pers. comm. December 29, 1988).

The mainstem Androscoggin River supports very productive warm and cold water fisheries. Above Berlin, New Hampshire the major fish species are brook trout, brown trout, rainbow trout, landlocked salmon, chain pickerel, yellow perch, and smallmouth bass (PAL). The New Hampshire Department of Fish and Game stocks put and take brook and rainbow trout and put and grow brown trout and landlocked salmon (L. Miller, pers. comm. Jan., 3, 1989). Below Berlin, the rainbow trout fishery is maintained to same degree by natural reproduction (PAL). There is considerable natural brook and rainbow trout reproduction from the tributaries contributed to the Androscoggin River but high flows limit spawning in the mainstem river (L. Miller pers. comm. Jan. 3, 1989).

The lower mainstem Androscoggin River supports predominantly stocked brown trout. Other salmonids, largemouth bass, and an excellent smallmouth bass fishery are also present (Dennis McNeish, pers. com. 12 Dec. 1988).

Anadromous fish in the Androscoggin River are confined to the reach below Lewiston Falls, the historical limit of anadromous species except Atlantic salmon. Maine is currently in the process of restoring anadromous fish runs in the Androscoggin Basin. Since 1983, alewives, American shad, sea run brown and brook trout, and Atlantic salmon have been trapped at the Brunswick dam and trucked to mainstem and tributary sites below Lewiston Falls. The Maine Department of Marine Resources is currently stocking alewives in lakes and ponds throughout the Little Androscoggin River basin. They will be stocking shad in the basin as they are collected at Brunswick or transferred from other rivers (PAL). American shad spawn from mid-May through June and the river serves as a nursery till fall (T. Squires, pers. com. 9 Jan. 1989). Three dams are in place on the Little Androscoggin River. Two of these have fish passage structures and a structure is under construction on the third (T. Squire, pers. com. 9 Jan. 1989).

The Sabbatus River was stocked with alewives in the past but this program is presently on hold. Restoration to the Sabbatus River is still part of the State restoration program (T. Squire, pers. com. 9 Jan. 1989). Atlantic salmon historically occurred in the Nezinscot River, but no plans exist to restore this species to the river in the near future (E. Brown pers. comm. 9 Jan. 1989).

The mouth of the Androscoggin River at Merrymeeting Bay is used by smelt, striped bass (Morone saxatilis), and sea run brown and brook trout (J. Boland, pers. comm. 29 Dec. 1988), and short nosed sturgeon (Acipenser brevirostrum) (T. Squire, pers. comm. 9 Jan. 1989).

5. Wetland Resources

In general the mainstem Androscoggin River supports few riparian wetlands except where its flow is constricted as at the numerous dams along its length and at the lower extremes of the river. The majority of the river would be classified as Riverine-Upper Perennial-Rock Bottom according to the U.S. Fish and Wildlife Service classification system (Cowardin et al. 1979) because of its rapid flow and limited floodplain. The tributaries to the Androscoggin River appear to support more wetlands than the mainstem river. The subclasses and dominance types of wetlands in the basin vary from north to south. The northern wetlands of the Rangeley Lakes region appeared to be most of ten dominated by needle-leaved evergreen and deciduous forested wetlands, broad-leaved deciduous scrub-shrub wetlands, and persistent emergent wetlands. Dominance types includes northern white cedar, black spruce, and larch in forested wetlands; speckled alder, sweet gale, and leatherleaf in scrub-shrub wetlands; and sedges (Carex spp.) an emergent wetlands.

Table 2. Wetland Plants Observed During Androscoggin River Basin Field Investigations (November 2, 3, 4, 1988).

| | |
|---|---|
| **Trees** | |
| Acer rubrum | Red maple |
| Betula populifolia | Gray birch |
| Fraxinus sp. | Ash |
| Ulmus sp. | Elm |
| Thuja occidentalis | Northern white cedar |
| Picea | Black spruce |
| Abies balsamea | Balsam fir |
| Larix laricina | Tamarack |
| **Shrubs** | |
| Alnus rugosa | Speckled alder |
| Salix nigra | Black willow |
| Cornus amomum | Silky dogwood |
| Spirea latifolia | Meadowsweet |
| Rosa palustris | Swamp rose |
| Chamaedaphne calyculata | Leatherleaf |
| Myrica gale | Sweet gale |
| Kalmia angustifolia | Sheep laurel |
| Rhododendron viscosum | Swamp azalea |
| Andromeda glaucophylla | Bog-rosemary |
| Viburnum cassinoides | Wild raisin |
| Viburnum recognitum | Arrow-wood |
| Ilex verticillata | Winterberry |
| Salix discolor | Pussywillow |
| **Emergents** | |
| Glyceria sp. | Manna grass |
| Phalaris arundinacpa | Reed canary grass |
| Carex stricta | Tussock sedge |
| Carex spp. | Sedge |
| Onoclea sensibilis | Sensitive fern |
| Osmunda cinnamomea | Cinimom fern |
| Osmunda regalis | Royal fern |
| Scirpus cyperinus | Woolgrass |
| Equisetum sp. | Horsetail |
| Eleocharis sp. | Spike rush |
| Typha sp. | Cattail |
| Calamagrostis sp. | Bentgrass |
| **Other** | |
| Sphagnum sp. | Sphagnum moss |

Just south of Umbagog Lake to about Pontook Reservoir wetlands associated with the Androscoggin River are transitional between the upper and lower basin. Wetlands of the southern portions of the basin appear to most frequently fall within the broad-leaved deciduous forested and scrub-shrub wetland and persistent emergent wetland classes and subclasses. Dominance types most often consisted of red maple forest, speckled alder and meadowsweat scrub-shrub plants, and a variety of emergent species.

The wetlands of the Androscoggin River system associated with this project, in general, have high wildlife value because, by definition, they are associated with lake open water or riverine habitat. In addition, since much of the basin has little human development, especially the Rangeley Lakes region, the value of the wetlands is enhanced by adjacent natural upland habitat types. Wetlands identified as having especially high wildlife value are the wetland complex at the outlet of Kennebago Lake, the Umbagog Lake wetland complex, the wetland surrounding the Dead River outlet of Androscoggin Lake, wetlands on the Nezinscot River at the dam in Turner, and seven wetlands on the Little Androscoggin River rated as having high wildlife value (PAL; E. Dumont, pers. comm. 11 Jan. 1989; P. Bozenhard, pers. comm. 11 Jan. 1989).

Wetlands can be found at all of the Rangeley lakes, however, wetland distribution varies widely. The shorelines of the lakes are generally rocky with upland vegetation extending to the waters edge. Lake water level fluctuation is a major factor limiting emergent wetland formation on the Rangeley Lakes. With the exception of Umbagog Lake, emergent wetlands are primarily found in the lower energy environments within coves or at the mouth of tributaries, e.g., Metallak Brook on Upper Richardson Lake and South Bog Stream on Rangeley Lake (PAL). In some cases, as on Richardson Lake near the Mooselookmeguntic Dam, scrub-shrub or forested wetlands are present on the shoreline edge or at the entrance of tributary streams but separated from the open water by exposed shoreline. This suggests that these wetlands may be dependent on upland surface, soil, or groundwater rather than lake water levels or that the current water management regime is sufficient to maintain these wetland types. Sedges and grasses growing between the vegetation line and open water suggest that water levels in these areas have been low for much of the growing season.

Scrub-shrub and emergent wetlands are present at most of the mainstem impoundments. Dominant plants in the wetlands are the tall shrub, speckled alder, or a variety of emergent plants.

All four of the tributaries under consideration for new storage reservoirs, i.e., the Webb, Ellis, Sabbatus, Swift, Nezinscot, and Little Androscoggin Rivers, have significant wetland areas within their drainages. Most of the headwater lakes and ponds, particularly Webb Lake and Androscoggin Lake, have peripheral wetlands that are important for wildlife. Gulf Island Pond has limited associated wetlands as a result of its pronounced water level fluctuations. Habitat evaluation studies are underway as part of the FERC relicensing process to quantify the effect of water level fluctuations on wetlands and wildlife communities at the Gulf Island Dam Project (PAL).

## 6. Terrestrial Resources and Wildlife

### a. Forest Resources

The Androscoggin River Basin falls within the Northern Hardwoods Forest Region also described as the hemlock-white-pine-northern hardwoods region or beech-birch-maple-hemlock type (Young 1982). The principal tree species of this region are listed in Table 1.

Red maple, white birch, oaks, and white pine are most common in southern positions of the basin. In northern portions of the basin balsam fir, red spruce, hemlock, white pine, and white birch are common. The upper Androscoggin River Basin in the Rangeley Lakes Region contains extensive softwood, hardwood, and mixed timber stands. Timber harvesting is the primary land use with balsam fir, red spruce and yellow birch among the important commercial tree species (PAL).

Table 1. Some Important Species of the Northern Hardwoods Region

| Region<br>Scientific Name | Common Name |
|---|---|
| Fagus grandifolia | American beech |
| Betula allegheniensis | Yellow birch |
| Acer saccharum | Sugar maple |
| Tsuga canadensis | Eastern hemlock |
| Pinus strobus | Eastern white pine |
| Acer rubrum | Red maple |
| Pinus resinosa | Red pine |
| Populus grandidentata | Bigtooth aspen |
| Quercus rubra | Northern red oak |
| Fraxinus americana | White ash |
| Ulmus americana | American elm |
| Thuja accidentalis | Northern white cedar |
| Tilia americana | American basswood |
| Prunus serotina | Black cherry |
| Picea rubens | Red spruce |
| Pinus banksiana | Jack pine (Young 1982) |
| | |
| Betula papyrifera | Paper birch |
| Picea glauca | White spruce |
| Populus tremuloides | Quaking aspen |
| Picea mariana | Black spruce |
| Larix laricina | Tamarack |
| Abies balsamea | Balsam fir |
| Pinus banksiana | Jack pine |

b. <u>Wildlife</u>

The Rangeley Lakes region is relatively undeveloped and provides high quality habitat for a variety of wildlife species. White-tailed deer are one of the most important game species in the area. Moose are also common. Other mammals likely to occur in the study area include: black bear, coyote, red fox, bobcat, fisher, marten, weasel, river otter, mink, raccoon, striped skunk, musckrat, beaver, porcupine, snowshoe hare, red squirrel, and small mammals such as shrews, mice and voles. Wildlife observed during the November 1988 site visit by the Corps and Fish and Wildlife Service include bobcat, moose, common loon, bufflehead, common merganser, hooded merganser, bluejay, snow bunting, junco, chickadee, ruffed grouse, great blue heron, red squirrel, red- tailed hawk, osprey, Cooper's hawk, raven, crow, and ring-billed gull (PAL).

Semi-aquatic furbearers such as otter, mink, muskrat, and beaver are uncommon in the Rangeley Lakes except for Lake Umbagog due to the adverse consequences of lake water level fluctuations. Large water level fluctuations do not provide stable conditions for the establishment of emergent and submergent aquatic vegetation which provides food and cover for fish and wildlife. The "ring" of unvegetated area between open water and upland vegetation creates conditions unfavorable for the establishment of animal dens. Water level fluctuations also adversely affect loon and waterfowl nesting.

The wildlife component of habitat is highly reflective of and dependent on the vegetation and physical components of the habitat. Therefore, the value of wildlife habitat is assessed based on these qualities. Descriptions of important habitat areas identified at the reconnaissance level follow.

A number of unique wildlife areas are found in the Rangeley Lakes region. There is a very high quality wetland complex at the outlet of Kennebago Lake that supports excellent waterfowl production. The Kennebago River has been designated a Class "B" river in the Maine Rivers Study, denoting outstanding statewide resource values. Resource values specifically identified in the Study include: high quality wetlands important to waterfowl and furbearers; a major white-tailed deer wintering area near the mouth of Kamankeag Stream: as well as one of Maine's most outstanding inland fishing rivers for native brook trout and landlocked salmon (PAL).

The Rapid River, which flows six miles from Middle Dam to Umbagog Lake, has also been designated a Class "B" river in the Maine Rivers Study. Outstanding resource values include: a major deer wintering area along the river; important loon nesting islands at the mouth of the river in Umbagog Lake; significant brook trout and landlocked salmon resources; and one of the highest quality and most popular white water boating runs in the state. The Rapid River White Water Rapids are also designated as a State Registered Critical Area (#458) due to the high white water boating values and presence of a unique old-growth white pine stand along its banks. This stand is the largest stand of virgin pine and has the largest average tree size of any pine stand in the state (PAL).

Umbagog Lake was included in the Fish and Wildlife Service's 1979 Unique Ecosystem Concept Plan. The lake is considered one of the finest waterfowl areas in New Hampshire and is one of the most important breeding grounds for common loon in the northeast. Loon breeding habitat here is considered to be significant and unique due to the high habitat diversity and lack of disturbance. There are over 8000 acres of prime black duck nesting habitat within the Umbagog Lake wetland complex. Other waterfowl species that commonly breed in and around the reservoir include: goldeneye, ring-neck duck, wood duck, hooded merganser, and common merganser. Ruffed grouse, snipe, and woodcock are among the important upland game birds in the area. There is a great blue heron rookery that supports 20 to 30 heron pairs. Both Aziscohos and Richardson Lakes also have heron rookeries. The rookery on Aziscohos is on an island and could be affected if water levels are increased, causing the nesting trees to die. There are six active osprey nests and one inactive bald eagle nest. Umbagog Lake has the only breeding colony of ring-billed gulls in Maine. It is the one reservoir in the Rangeley Lakes area that supports significant populations of furbearers, due primarily to more stable water levels which allow aquatic vegetation to flourish (PAL).

All of the Rangeley Lakes have resident loons. The primary factor limiting loon production on all of the reservoirs is water level fluctuations during the critical nesting period. Loons must nest at the waters edge since their body is adapted for swimming and they cannot walk upright on land. A rise in lake water levels as little as 0.5 feet can inundate the nest and destroy the clutch. Decreasing water levels expose shoreline between the nest and the waters edge, and thus prevent the birds from reaching the nest to protect and incubate the eggs. The effect of declining water levels is dependent on the slope of the shoreline. Drops of 1.5 vertical feet or less can be sufficient to prevent access by adult birds and thus cause nest failure. Attention has been focused on the Aziscohos Lake Loon population as part of the FERC license proceedings. A comprehensive study of loon nesting documented 26 resident loons on the lake. Ten nesting pair were recorded in 1987. Because of the severe consequences of lake level fluctuation, artificial loon nesting islands are being experimentally evaluated as a condition of the FERC license. There are many site-specific factors that affect the potential success of artificial nesting islands. Generally, they are considered to be of limited usefulness in mitigating the adverse effects of water level fluctuations (PAL). Peter Cross of the Maine Department of Inland Fisheries and Wildlife (pers. comm. 5 Jan. 1989) indicated that the initial results of these experimental nesting efforts showed reasonably good success, but that alot of maintenance and monitoring is required. During later study phases it will be necessary to assess impacts to loons and potential mitigation if the water level management alternatives remain. The Loon Preservation Committee would be contacted at that time.

The mainstem Androscoggin River and tributaries downstream of the Rangeley Lakes appear to have high wildlife value in undeveloped areas. A thorough inventory of specific sites has not been completed for the reconnaissance study however several particularly valuable areas have been identified by the Maine Department of Inland Fisheries and Wildlife and the U.S. Fish and Wildlife Service.

Wetlands on the Little Androscoggin River and Nezinscot River in Region A have been rated for their value to waterfowl. There are seven high value wetlands, six moderate value wetlands, and six low value wetlands on the Little Androscoggin River and its tributaries. On the Nezinscot River in Region A there is one high value wetland, two moderate value wetlands, and one low value wetland. There are also two historic deer wintering areas (these areas have not been surveyed in 8-10 years) on the Nezinscot River. One is located at Russel Brook in Sumner and the other is located at Jersey Bog in Buckfield (P. Bozenhard, pers. comm. 11 Jan 1989).

In Region B, the Nezinscot River is described as valuable for waterfowl west of Route 4 with very high value at the dam in Turner. Its value also increases at its junction with the Androscoggin River.

Dead River and its source, Androscoggin Lake, are described as having high wildlife value. Slow moving portions of the river are valuable for furbearers and waterfowl. Androscoggin Lake, especially at the outlet, where a peninsular of marsh extends into the lake is valuable for wildlife (E. Dumont, pers. comm. 11 Jan. 1989). The lake receives significant waterfowl use, attracting species such as redheads and pintails that are not commonly found on other lakes in the region. Perimeter wetlands are important for waterfowl and loon production. Lothrup Island supports a major heron rookery, as well as an active osprey nest and an inactive bald eagle nest (PAL).

The Sabbatus River is described as having high quality habitat for waterfowl, furbearers and shorebirds from the Androscoggin River north to Route 126 (E. Dumont, pers. comm. 11 Jan. 1989).

The western shore of Gulf Island Pond from Twitchell Airport north for four miles is undeveloped and has very good riparian habitat. The islands provide good furbearer habitat for species such as raccoon, otter, mink, and beaver. A deer yard is present at Bradford Brook (E. Dumont, pers. comm. 11 Jan. 1989).

7. <u>Threatened, Rare, and Endangered Species</u>

The U.S. Fish and Wildlife Service has determined that the headwater reaches of the Androscoggin River Basin have sites with a strong potential for nesting by peregrine falcons (Falco peregrinus) (Correspondence dated August 22, 1988 and Planning Aid Letter (Appendix A) dated December 21, 1988). Potential aerie (cliff nest) sites are near the mainstem river in the Gilead-Bethel vicinity. Also, the project area includes two historic bald eagle nests that could potentially be used again in the future. These are located at Umbagog Lake and Androscoggin Lake.

Maine DIFW indicates there has been a great deal of use by bald eagles along the Kennebago River, Cupsuptic River, and the Androscoggin River from Bethel to Rumford and around the Richardson Lakes. Additionally, Umbagog Lake and the Megalloway River north to Canada are used by golden eagles which are listed as endangered in Maine (P. Cross, pers. Comm. 5 January 1989).

Short nosed stugeon are present in Merrymeeting Bay. They spawn just after ice-out and may be affected if the spring freshet is reduced (T. Squire, pers. comm. 9 Jan. 1989).

B. ENVIRONMENTAL CONSIDERATIONS

Since specific design proposals are not available at this time it is not possible to concisely predict potential impacts. Because of the large number of options available and their magnitude, the quality of the resources in the basin, and the complexity of the existing water management program, the potential for significant impacts is great. Three general options are being considered to reduce downstream flooding. These are: reregulation of flows from existing dams, construction of dams on tributaries to the Androscoggin River, and an early warning/flood forcasting system. An early warning system by itself would have no impacts.

1. <u>Reregulation</u>

Reregulation to increase flood storage capabilities would involve one or more of the following: increasing annual lake drawdowns to provide additional storage; surcharging the reservoirs or increasing the height of water control structures to provide additional storage; and/or changing reservoir refill/drawdown sequencing to provide additional storage capacity during peak runoff events.

The Rangeley Lakes are currently managed to store runoff and snowmelt during the spring months for gradual release during the summer and fall to provide uniform flow conditions in the mainstem Androscoggin River for downstream power and industrial water users. The mainstem dams also supply hydropower. Incidental benefits from the current operational regime include flood control for the valley below Errol and augmented flow conditions for whitewater boating and fishing during the natural low flow period.

Water level fluctuation in the Rangeley Lakes is presently a major factor affecting fish and wildlife productivity in the Rangeley Lakes and Mainstem reservoirs. Impacts from increasing the magnitude of annual water level fluctuations would include the following:

1. Changes in the reservoir fill schedule could affect in stream flow releases below the dams. Negotiations over in stream flow releases will be underway at Aziscohos Dam and Middle Dam as part of the FERC licensing process. Instream Flow Incremental Methodology (IFIM) flow studies have been conducted at both projects, and will be the basis for specific flow recommendations. Any changes in the lake flow releases will have to be made within the framework of the in stream flow levels eventually adopted as license conditions for these projects.

The high level of regulation existing in the Androscoggin Basin lakes means that extensive coordination will be necessary to ensure that any additional regulation for flood control is workable within the framework of the existing water management plans. Possibilities for low flow augmentation exist because of poor water quality conditions. The cold water fisheries in the lower Androscoggin River are described as borderline by Maine DMR (J. Boland, pers. comm. 29 Dec. 1988). Any improvement in water quality would have positive effects on the fishery. Conversely, any degradation of water quality could have potentially significant negative effects. Further upstream in the river in New Hampshire high flows are considered a problem limiting spawning in the Androscoggin River. Studies have suggested that decreased flows would increase wetted usable area and fishing access (L. Miller, pers. comm. 3 Jan. 1989). This suggests that some positive environmental effects could be achieved through reregulation but that a workable plan would be difficult to define because of the numerous competing interests.

2. Reductions in lake levels could affect water quality by changing stratification characteristics. Changes in water quality parameters such as temperature and dissolved oxygen could affect downstream riverine fisheries as well as reservoir fish resources.

3. Increasing the drawdown could affect fish passage into spawning and refuge tributaries during low water conditions. As lake levels recede, tributary flow may become spread out over broad alluvial deposits (since water flows over the path of least resistance, flow in rills is also possible) or pass over waterfalls at stream mouths. Fish attempting to move upstream could be subjected to shallow water depths, impassable falls, higher temperatures, and/or predation. This is a critical issue since the salmonid and smelt fisheries are supported almost exclusively by natural production in lake tributaries. Access to cold water refuge habitat in lake tributaries is also critical for salmonids in Aziscohos Lake where water quality may become stressful by the end of the summer. Specific stream surveys during low water periods would be necessary to quantify the extent of this potential problem at each reservoir.

4. Additional lake drawdown could affect the aquatic food base for fish by reducing the area of productive littoral zone available for invertebrate food production depending on hydrography of the lake bottom. Insects and other aquatic invertebrates such as freshwater clams and mussels may be adversely affected by increased littoral zone exposure.

5. Increasing the magnitude of lake level fluctuations could exacerbate conditions that presently affect lake trout spawning in the Richardson Lakes. While not a problem at this time, because lake trout spawning would increase competition with existing fish populations, future management opportunities for natural lake trout production may be adversely affected.

6. Reduced lake water levels could have adverse consequences for emergent wetland and submergent aquatic vegetation in the Rangeley Lakes. This could reduce available habitat for fish and wildlife, such as furbearers and waterfowl, dependent on this vegetation. Effects from wetland plant losses would extend beyond those animals dependent on these plants for food and cover. The loss of vertebrate and invertebrate prey organisms associated with aquatic plant communities could affect the entire food web.

7. Waterfowl and loon nesting/brooding activities could be affected by increased water level fluctuations although waterfowl nesting is limited in all but Umbagog Lake because of existing water level fluctuations. Surcharging the reservoirs during the spring runoff period could flood either newly established nests or traditional nesting sites. Permanently

raising reservoir levels would also flood traditional nesting sites. New potential nesting sites may be reduced or increased depending on surrounding topography and vegetation. Increasing reservoir drawdown during the spring and early summer months would decrease loon production by making their nest sites inaccessible. Waterfowl production may be similarly affected. Brood habitat would be impacted by reduced littoral productivity and nearshore cover availability.

8. Permanent water level increases would destroy or change surrounding upland vegetation. Permanent increases in lake water levels could flood cedar swamp deer yards or kill live nest trees in heron rookeries. The island rookery on Aziscohos Lake may be particularly vulnerable to flooding.

9. Lake level changes in Umbagog Lake could affect the unique floating bog communities there, including Floating Island, a National Natural Landmark administered by the Nation Park Service.

2. <u>New Dam Sites</u>

Several tributaries of the Androscoggin River are considered for potential sites for flood control dams. These tributaries are the Ellis, Swift, Webb, Dead, Nezinscot, Sabbatus, and Little Androscoggin Rivers. No specific sites were proposed at the time of this writing, but, in general, new flood control dams have the potential for significant environmental impacts. The Fish and Wildlife Service describes all of the basins listed as having significant fish and wildlife resources. Potential impacts of new flood storage sites are described below.

1. The primary impacts would be the permanent loss of habitat from the construction of dams, access roads, and associated structures, and changes in habitat in the storage area. Clearing the storage area would result in the alteration of existing habitats including the highly valued riparian zone vegetation, surrounding forests, and depending on the site, streamside wetlands. Streamside habitats generally have high wildlife value because of the increased diversity of habitat where two or more habitat types come together. Open, unvaried habitat would be associated with a poolless reservoir. If a pool is associated with the dam the habitat would change to open water. This change would result in the elimination of riverine habitat as well as surrounding upland habitats. If the pool water level were stable, shoreline wetlands could form.

2. With the changes in habitat with dam construction, there would be a change in the associated wildlife. Overall, the construction would be expected to have detrimental impacts to

wildlife and fisheries. The impacts to wildlife would affect year-round and seasonal users of the habitat as well as those species which use the riparian corridors as migration routes. Depending on the design and placement of the structures, the impacts could be significant, requiring the preparation of an Environmental Impact Statement.

3. Fishery habitat values would change, and possibly increase as a result of low flow augmentation on tributary streams. However, existing fishery resources in the impact zone would generally be negatively affected by new flood control reservoirs. Among the direct aquatic habitat impacts would be the loss of cover, shade, and terrestrial food inputs from the removal of streamside vegetation in the impoundment zone. Substrate suitability for spawning and food production could be reduced as a result of sediment deposition behind the dam. Additional sediment sources may develop from the loss of vegetative cover and periodic flooding of the impoundment area. Increased sediment levels can adversely affect fish eggs, fish gills, and can reduce habitat quality by filling in pools and smothering productive riffles. If permanent pools are created riverine coldwater fish habitat would most likely change to warmwater habitat.

4. Aquatic habitat downstream of the dams would change. The sediment load inflows would be deposited upstream of the dams where current velocity and turbulence decrease. As a result, the downstream portions of streams would become armored, that is, the channel bed would be covered with a layer of course gravel, cobble, and boulders. This could affect the suitability of the substrate for spawning for the coldwater and warmwater fish species residing in the streams. That sediment collected behind the dam could be flushed downstream during flood water releases increasing tailwater turbidity. Changes in downstream aquatic communities and water quality can also occur as impoundment organisms and chemical constituents and low dissolved oxygen waters are flushed downstream during release of flood flows (Nestler et al. 1986).

## C. COORDINATION

The following agencies have been contacted by letter or telephone communication during the development of this report. Those agencies which responded provided most of the technical information provided in this report.

U.S. Fish and Wildlife Service,
National Oceanic and Atmospheric Administration - Fisheries
Environmental Protection Agency-Region 1,
Maine Department of Inland Fisheries and Wildlife,
Maine Department of Marine Resources,
Maine Atlantic Sea Run Salmon Commission,
Maine Critical Areas Program,
New Hampshire Office of State Planning,
New Hampshire Fish and Game Department,
New Hampshire Natural Heritage Inventor.

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ANDROSCOGGIN RIVER BASIN

WATER RESOURCES STUDY

APPENDIX D

HEC-1 BASIN MODEL

ANDROSCOGGIN RIVER BASIN
WATER RESOURCES STUDY

APPENDIX D

HEC-1 BASIN MODEL

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1. PURPOSE OF MODEL

The HEC-1 Computer Model of the Androscoggin River Basin was developed to:

a) Simulate the effects of adding flood storage at various points in the basin, on downstream peak flood stages, and hydrograph development times.

b) Test the impacts of regulation of existing basin storage on flood peaks and timing.

c) Determine the sensitivity of basin hydrographic modelling to data parameters such as temperature, rainfall, snowpack, etc. The objective here is to aid in the selection of the number and timing of these measurements for a flood forecasting system.

The model was prepared and calibrated by the firm of Roald Haestad Inc., of Waterbury Connecticut, under contract with the New England Division. Close liaison was maintained during the data acquisition and calibration phases so that when the final model was delivered, experience had already been gained in achieving the aforementioned objective c.

Further simulations were performed within Planning Division at NED.

2. DATA ACQUISITION

The data used in preparing the HEC-1 Model for the Androscoggin River Basin was obtained from various agencies including New England Division of the Corps of Engineers, United States Geological Survey, NWS-River Forecast Center, National Oceanic and Atmospheric Administration, National Weather Service, and Union Water Power Company. Additional data were obtained from the owners of the dams located along the main stem of the Androscoggin River.

Rainfall - The rainfall data was obtained from the National Oceanic and Atmospheric Administration and the NWS-River Forecast Center.

The hourly rainfall gauge at Pinkham Notch, New Hampshire and the 24-hour gauge at Rangeley, Maine were not used because the recorded rainfall was almost double that recorded at surrounding gauges.

Snow - Snow depth within the Androscoggin River Basin on March 29, 1987 was obtained from the NWS-River Forecast Center. The Union Water Power Company does a snow survey of the Androscoggin River Basin which provided data as of the beginning of March. Snow depths were also taken every two weeks at their dam sites. From these data sources snow depth contours were plotted over the basin.

A Report entitled "The Flood of April 1987" by the Land and Water Resources Center, University of Maine, reported the snowpack was "ripe" and the density of the snow was around 35%. The snow depth was converted to inches of water by multiplying by a factor of 0.35.

Temperature - The temperature data for the stations within or adjoining the Androscoggin River Basin were obtained from NOAA National Climatic Data Center. All the stations record maximum/minimum temperatures for a 24 hour period, except for Mount Washington, New Hampshire and Augusta, Maine; which record hourly temperatures, and Portland, Maine, which records temperature every three hours. The temperature readings at Portland were converted to hourly readings by straight line interpolation.

The Union Water Power Company takes temperature readings at 7:00 a.m. and at 2:00 p.m. at their dam sites.

A temperature lapse rate per 1,000 feet of elevation was calculated by comparing the average daily temperature for the stations within the first elevation zone to the stations within the second elevation zone. The Androscoggin River Basin has six elevation zones and a lapse rate of 2.8 degrees was calculated. In the HEC-1 Model a lapse rate of 3 degrees per 1,000 feet of elevation was used.

The maximum/minimum temperature readings were converted to hourly readings using the temperature distribution observed at the hourly and three hour recording stations.

Streamflow Gauging Record - The United States Geological Survey Office in Maine provided hourly gauge heights and rating curves for the nine gauging stations that were in operation during the flood event. The gauge heights were converted to discharges using the rating curves supplied by USGS.

Central Maine Power supplied hourly discharges from Gulf Island Dam. The Union Water Power Company supplied hourly and average daily discharges for the Little Androscoggin River gauge in Auburn. The Union Water Power Company also supplied average daily discharges for the gauges on the Androscoggin River at Bog Brook, New Hampshire; Dummer, New Hampshire; and Gilead, Maine.

At the Gilead, Maine gauge, a high water mark elevation was also supplied by the Union Water Power Company. The high water mark was higher than the rating table for the gauge, therefore the rating table was plotted and extrapolated in order to estimate the peak discharge. A peak discharge of 56,500 cfs was determined by extrapolating the gauge rating curve and a peak discharge of 51,050 cfs was calculated with the HEC-1 computer model.

A plot of the observed hydrographs are shown on Plates 1 through 11, following page D-11.

Routing Information - The routing of the hydrographs down the Androscoggin River was done using cross section information from FEMA Flood Insurance Studies (FIS), where available, and cross sections taken from 1"-2000' USGS Quadrangles with 20' and 10' contour intervals.

HEC-2 input data files used in the FIS for the Communities of Brunswick, Lewiston, and Rumford, Maine; and Berlin, New Hampshire were used. Input data files for FIS Lisbon, and Mexico, Maine could not be located. The available data was entered into the computer files and several runs of the backwater models were made to develop storage-discharge curves for each section. The starting water surface elevations were approximated using a graph of elevation versus discharge compiled from information shown in the respective FIS's.

The USGS office in Augusta, Maine had the FIS input files for the Towns of Livermore, Jay, and Canton, Maine on their computer system. The Union Water Power Company supplied the storage and discharge data for Errol Dam and all the upstream dams owned and operated by them. The storage data for Errol Dam, Middle Dam, Upper Dam, and Rangeley Dam were calculated by the Union Water Power Company assuming a constant surface area. Daily logs of the dams were also obtained.

The storage and discharge data for the dams downstream of Errol Dam, where available, were obtained through the Union Water Power Company from the individual dam owners.

3. MODEL DEVELOPMENT

The March-April 1987 flood event was selected as the basis for the HEC-1 model of the Androscoggin basin principally because the data required for the model was most readily available.

Locations for hydrograph development were selected based on knowledge of damage areas in the basin. In addition to these locations, the gauged watersheds were analyzed in order to calculate unit hydrograph and loss rate parameters for use at ungauged watersheds.

The Androscoggin River Basin was subdivided into 29 watersheds for the purposes of the HEC-1 model.

The first step in the modeling process was to collect general information for each watershed such as watershed size, the portion of watershed in each elevation zone for snowmelt calculations, the time-area table for use with the Clark Unit Hydrograph, average rainfall, snow depth, and temperature information.

The watershed size for each of the analysis points was obtained from USGS, Union Water Power Company, and FIS Reports for the various communities.

The Androscoggin River Basin was divided into elevation zones by tracing the contours from the watershed map. The zones were set up in elevation increments of 1000 feet. The portion of each watershed within an elevation zone was entered in the HEC-1 model for use in calculating snowmelt.

The time-area table for use with the Clark Unit Hydrograph was determined by measuring the longest stream in the watershed and dividing it into equal segments. At each segment isochrones were drawn on 2 watershed maps so that the travel time along the watercourse was the same from one isochrone to another. The area between each pair of isochrones was plainimetered and the values entered in the HEC-1 model.

The average rainfall for each watershed was determined using the Thiessen Method. In the Thiessen Method, it is assumed that the amount of precipitation at any rainfall gauge can be applied halfway to the next rainfall gauge in any direction. The area of influence of each station was obtained by constructing polygons determined by drawing perpendicular bisectors to lines connecting the rainfall gauges. The bisectors are the boundaries of the effective area for each rainfall gauge. The area of each rainfall gauge effective area within each watershed, was planimetered and a weighted percentage calculated The rainfall amount and corresponding weight for each gauge affecting the watershed were entered into the HEC-1 Model for use in calculating the average rainfall over the watershed. At some watersheds where topographic features influenced the precipitation, the weighting factors calculated with the Thiessen Method were adjusted to reflect the more likely conditions.

The snow depth for each watershed was estimated from the contour map obtained from the NWS-River Forecast Center and snow depths obtained from the NOAA National Climatic Data Center. The snow depth was converted to inches of water by multiplying by a factor of 0.35.

The temperature information was obtained from the NOAA National Climatic Data Center. The hourly temperature recording stations are located at Mount Washington, New Hampshire (EL. 6262), Augusta (EL. 350) and Portland, Maine (EL. 6262), Augusta (EL. 350) and Portland, Maine (EL. 43). Hourly temperature factors were calculated for each of the stations by dividing the hourly temperature by the average of the 24-hour maximum/minimum values. The average hourly temperature distribution was calculated by giving equal weight to all three stations. Average daily temperatures for each of the watersheds were calculated using temperature recording stations in the vicinity of the watershed. Hourly temperatures were calculated by multiplying the average daily temperature by the average hourly temperature distribution.

The hourly temperatures calculated for the watersheds tributary to the Union Water Power Company Dams were compared to the values observed at each dam, and found to be higher in the early morning hours and lower in the afternoon hours. The hourly temperatures for the Errol Dam watershed were recalculated using only the Mount Washington distribution and it was found that the temperatures in the early morning hours were higher than those calculated with the average distribution of all three stations. It was decided to use the average hourly temperature distribution from all three temperature recording stations.

## CALIBRATION

With all the basic data collected, the next step in the modeling process was to calibrate the model for the March-April 1987 flood. The Clark Unit Hydrograph, exponential loss rate function for rainfall, and the snowmelt loss rate function were used in preparing the HEC-1 Model. The snowmelt was calculated using the Degree-Day Method. The base temperature in the equation was set to 32 degrees. Precipitation was assumed to fall as snow if the temperature was less than the base temperature plus 2 degrees. Melt was assumed to occur when the temperature was equal to or greater than the base temperature.

The calibration was first done for all the gauged watersheds in order to determine loss rate and unit hydrograph parameters. Secondly, the results from the gauged watersheds were correlated with watershed characteristics for use in estimating unit hydrograph and loss rate parameters for the ungauged watersheds.

### Gauged Watersheds

Six of the fourteen gauging stations within the Androscoggin River Basin are located on tributaries to the Androscoggin River These watersheds were analyzed first and unit hydrographs and loss rate parameters calculated.

Initial estimates of times of concentration and Clark storage coefficients were calculated from each of the observed hydrographs. Initial estimates of the rainfall and snowmelt loss rate values, and the snowmelt rate coefficient were obtained from various publications. All the estimated values were entered in the HEC-1 data file and optimized. The optimization range for the hydrograph was limited to the main hydrograph.

The optimization results for the six gauging station showed a constant rain and snowmelt loss rate of 0.008 inches per hour. The rain and snowmelt loss rate of 0.008 inches per hour was used for all the ungauged watersheds. The snowmelt coefficient varied from 0.065 to 0.15 inches per degree-day. The Clark Unit Hydrograph parameters (Tc+R) were correlated graphically with various watershed parameters.

### Ungauged Watersheds

The model of the Androscoggin River Basin was analyzed in reaches. The reaches extend from gauging station to gauging station. At the upstream end of each reach, the observed hydrograph was input as an inflow. By analyzing the reaches in this fashion the accumulation of error from reach to reach was eliminated.

Initial estimates of time of concentration and Clark storage coefficient were obtained from the graphs prepared with the results from the gauged watersheds. The snowmelt coefficient was estimated and adjusted accordingly to match the observed reservoir levels and/or peak discharges. Because the snowmelt rate is a function of temperature, and adequate temperature data was sparse and of questionable validity, the calculated snowmelt coefficients do not have high confidence levels.

The HEC-1 model was run with the initial parameter estimates, and the calculated hydrograph was compared with the observed hydrograph. If the two hydrographs did not match within tolerances, adjustments were made to the time of concentration, Clark storage coefficient, and snowmelt coefficient for each watershed within the reach, and the HEC-1 model was rerun. This step was repeated until the calculated hydrograph matched the observed hydrograph, within tolerances.

Routing

The level pool reservoir routing method was utilized at all dams where no backwater information from the FIS was available. At dams located within a reach where FIS data were available, the storage-discharge data from the backwater curve analysis was used.

Routings of the inflow hydrograph at Errol Dam had to be done in three steps, because during the flood event various gates were operated resulting in different discharges for the same lake level. The HEC-1 model is capable of accomodating declining with only a single value rating curve, and there are no provisions for changing the rating curve with time.

The routing of the hydrograph through the river channel was accomplished using the Modified Puls Routing Method. In reaches where no FIS data was available, the Normal-Depth Storage and Outflow procedure was utilized. The discharges were calculated using the Manning's Equation and the storage was calculated using the cross-sectional area times the reach length. For the reach from Gorham gauging station to the Rumford gauging station, this method gave poor results on the timing and attenuation of the hydrograph. It was decided to enter the sections taken from the USGS Quadrangles into a data file for the HEC-2 backwater program and compute storage discharge data for use in the HEC-1 Model. This method was also used for the reaches of river located in the Towns of Lisbon and Peru, Maine and Errol and Milan, New Hampshire.

For the reaches of river where FIS data was available, the storage-discharge data were calculated using the cross-section data from the studies. The storage-discharge relationships were obtained by calculating backwater profiles for several discharges to cover the range of the hydrograph to be routed.

High Water Marks

The USGS, subsequent to the March-April 1987 flood event, field surveyed high water marks at various locations along the Androscoggin River. Table 1 below gives the high water mark elevation field surveyed, compared to that calculated with the HEC-1 model.

TABLE 1

HIGH WATER MARKS ELEVATIONS
ALONG THE ANDROSCOGGIN RIVER

| RIVER MILE | DESCRIPTION | HIGH WATER MARKS FIELD SURVEYED * | ELEVATIONS HEC-1 MODEL |
|---|---|---|---|
| 109.3 | Route 2 Highway Bridge | 648.5 | 649.4 |
| 103.3 | Mouth of Bear River | 637.7 | 639.9 |
| 92.8 | Rumford Center, Maine at Town Meeting House | 623.3 | 620.4 |
| 87.6 | Bridge above Upper Dam | 618.2 | 614.2 |
| 82.3 | Bridge over Androscoggin R. | 415.1 | 416.9 |
| 72.1 | Dixfield Road | 395.2 | 393.8 |
| 69.2 | Route 140 near Stevens Is. | 392.6 | 389.8 |
| 66.7 | Riley Dam | 381.8 | 381.0 |
| 63.8 | Jay Dam | 360.3 | 358.4 |
| 61.8 | Otis Dam | 349.5 | 348.5 |
| 61.0 | Livermore Falls Dam | 321.4 | 320.9 |
| 49.2 | Turner, Maine @ Twin Br. | 281.7 | 280.2 |
| 34.8 | Gulf Island Dam | 264.2 | 263.1 |
| 30.8 | Union Water Power Co. Dam | 174.2 | 175.1 |
| 28.4 | Auburn USGS gauge | 132.9 | 133.7 |
| 16.1 | Worumbo Dam | 104.1 | 107.3 |
| 12.7 | Pejepscot Dam | 79.2 | 79.4 |
| 8.3 | Brunswick Dam | 51.0 | 51.1 |

* From USGS, Augusta, Maine

Computed Hydrographs

The hydrographs computed with the HEC-1 model were plotted on Figure 1. Panels 1 through 11 (following page D11) for comparison with the observed hydrographs.

MODEL ANALYSIS

In general, the model reasonably reproduces the parameters of the 1987 flood (to which it was calibrated), within tolerances. The greatest deficiencies in the modelling process were found to be:

1. Lack of accurate, timely temperature data throughout the upper and middle basin area during the storm period. Since it is temperature that ultimately distinguishes between snow accumulation and melt, the lack of sufficient recording points throughout the basin hampered the modelling process.

2. Inability of the HEC-1 model to accomodate multiple outflow characteristics at a reservoir, as a function of time. The gated structures at the outlets of the upper lakes were operated with many settings during the 1987 storm. With each discrete setting of all operable gates requiring a unique rating curve, reproduction of the actual conditions during the storm, was difficult.

It was also found that channel routing of the flood hydrographs by the Modified Puls Method resulted in poor correlation of predicted to actual, both in rate of development, and in peak flow. Utilization of input data sets from FIS to produce storage-discharge relationships, was a much preferable routing methodology.

MODEL SIMULATIONS

The model was run to test three different hydrologic variables:

1. Reregulation

During the March-April 1987 event, the water level at Errol Dam was 2 feet below the full level, and the upstream dams ranged from 11 to 28 feet below full. Consequently, the dams effectively stored the majority of runoff from the tributary watersheds.

Model runs were made to simulate conditions at Errol in which initial storage stages were higher. The resulting modified outflow hydrographs were then routed to the downstream damage centers.

TABLE 3

MAINSTEM ANDROSCOGGIN
STORAGE SIMULATIONS

| Simulation Run | Damage Centers | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| River Mile: | 90.2 | | 87 | | 78.4 | | 72.1 | | 34.8 | | 17.7 | | 14.1 | |
| Location: | RUMFORD | | MEXICO | | DIXFIELD | | CANTON | | AUBURN/ LEWISTON | | LISBON | | TOPSHAM | |
| | Stage[1] | Time[2] | | | | | | | | | | | | |
| Baseline condition | 616.8 | 67 | 439.4 | 67 | 403.1 | 64 | 393.9 | 65 | 263.2 | 74 | 108.8 | 78 | 81.7 | 77 |
| Expanded Pontook (at Dummer) | 616.2 | 66 | 439.1 | 66 | 400.9 | 63 | 393.6 | 64 | 263.0 | 73 | 108.7 | 76 | 81.5 | 76 |
| Equivalent storage @ R.M.101 (Hanover, ME upstream of Ellis R.) | 610.6 | 85 | 435.7 | 86 | 396.5 | 55 | 390.0 | 56 | 262.3 | 64 | 106.5 | 69 | 78.7 | 68 |
| Equivalent storage @ R.M.95.3 (downstream of Ellis R.) | 611.8 | 86 | 436.4 | 87 | 395.8 | 89 | 389.4 | 90 | 262.2 | 94 | 105.9 | 90 | 77.6 | 66 |
| 50% more storage @ R.M.95.3 | 608.8 | 110 | 434.6 | 110 | 394.9 | 51 | 388.6 | 52 | 262.2 | 61 | 105.6 | 65 | 77.6 | 65 |
| Equivalent storage @ R.M.74 (Canton, ME) | - | | - | | - | | 393.9 | 67 | 263.1 | 76 | 108.8 | 79 | 81.7 | 78 |

Notes:
1. Peak flood storage, NGVD.
2. Time in hours, from midnight 29-30 March, 1987.

Table 2 below summarizes the results of the model runs.

TABLE 2

| Run No. | Condition | Peak Outflow at Errol (CFS) | Data at Rumford Peak Flow (CFS) | Data at Rumford Stage (NGVD) |
|---|---|---|---|---|
| 1A | Base | 8,700 | 58,100 | 616.8 |
| 1B | Lake Level = 13 | 9,200 | 58,400 | 617.0 |
| 1C | " " = 15 | 11,000 | 59,200 | 617.2 |

Peak flows at the more downstream damage centers were even less impacted than those shown at Rumford.

2. Additional mainstem flood storage

The objective here was to simulate the addition of flood storage to the mainstem Androscoggin between Errol Dam and the most upstream of the damage centers evaluated. At Rumford, ME. the impacts of these strategies were measured at each of the principal damage centers in the form of reduction in peak flood stage.

The unit of storage which was added was the equivalent of flood storage from the original Pontook Dam which was formulated during an earlier Corps' study (1967). This amount of flood storage was simulated by modifying the storage-elevation-flow relationships at various points in the model.

The locations of the simulated storage additions, and the resulting effects on peak stage at the damage centers, are shown in Table 3.

3. Determination of lead time required for a Flood Forecasting System

One of the significant factors in estimating benefits from the operation of a basin-wide flood forecasting system is the amount of warning time provided. The shape and timing of flood hydrographs generated by the model provide a means of quantifying this parameter.

First, it was necessary to determine the latest time at which a warning could accomplish meaningful (property and life-saving) response. It was decided to use the most upstream major damage center (Rumford, ME), and the flood elevation at which significant damage began to occur. There are many structures in Rumford having their lowest openings between elevation 614 and 615 NGVD, and it was decided that 614 was the threshold elevation. The stage-frequency relationship for Rumford shows that this elevation is that of an approximately 10-year flood, which in turn relates, via flow-frequency, to about 38,000 CFS. The Rumford hydrograph (Panel 5) shows that this flow level was reached at 3:00 P.M. on 31 March 1987, or at hour 39 on the model scale. Therefore, it has been established that for this storm, any significant damage mitigation measures in Rumford would have to have been effected by hour 39.

Next, it was necessary to determine when a warning could reasonably have been issued. The flow gage at Gorham, N.H. was one potential site for taking measurements which would lead to a flood warning. The base (pre-model) flow at Gorham was approximately 3000 CFS. The hydrograph as routed from Errol by the model, indicated that the flow had doubled... to 6000 CFS, by hour 22. Using the doubling of a flow rate within a 24 hour period as a criterion of warning, it is reasonable to assume that such a warning could have been issued at hour 22. This would have provided 17 hours (39-22) of lead-time to Rumford.

There is another consideration, however. The Wild River, confluent to the Androscoggin at Gilead ME., had a much more dramatic rise. While not as great a contributor as the mainstem hydrograph, its rapid ascent was a clear indicator of later problems downstream. At 3:00 A.M. on 31 March 1987 (hour 27), the flow on the Wild was 2000 CFS, and increasing at the rate of 800 CFS/hour. Clearly, a warning could have been issued. The lead-time at Rumford in this case would have been 12 hours (39-27).

It was decided to use the more conservative (12 hour) figure in determining the economics of a flood forecasting system.

CONCLUSIONS

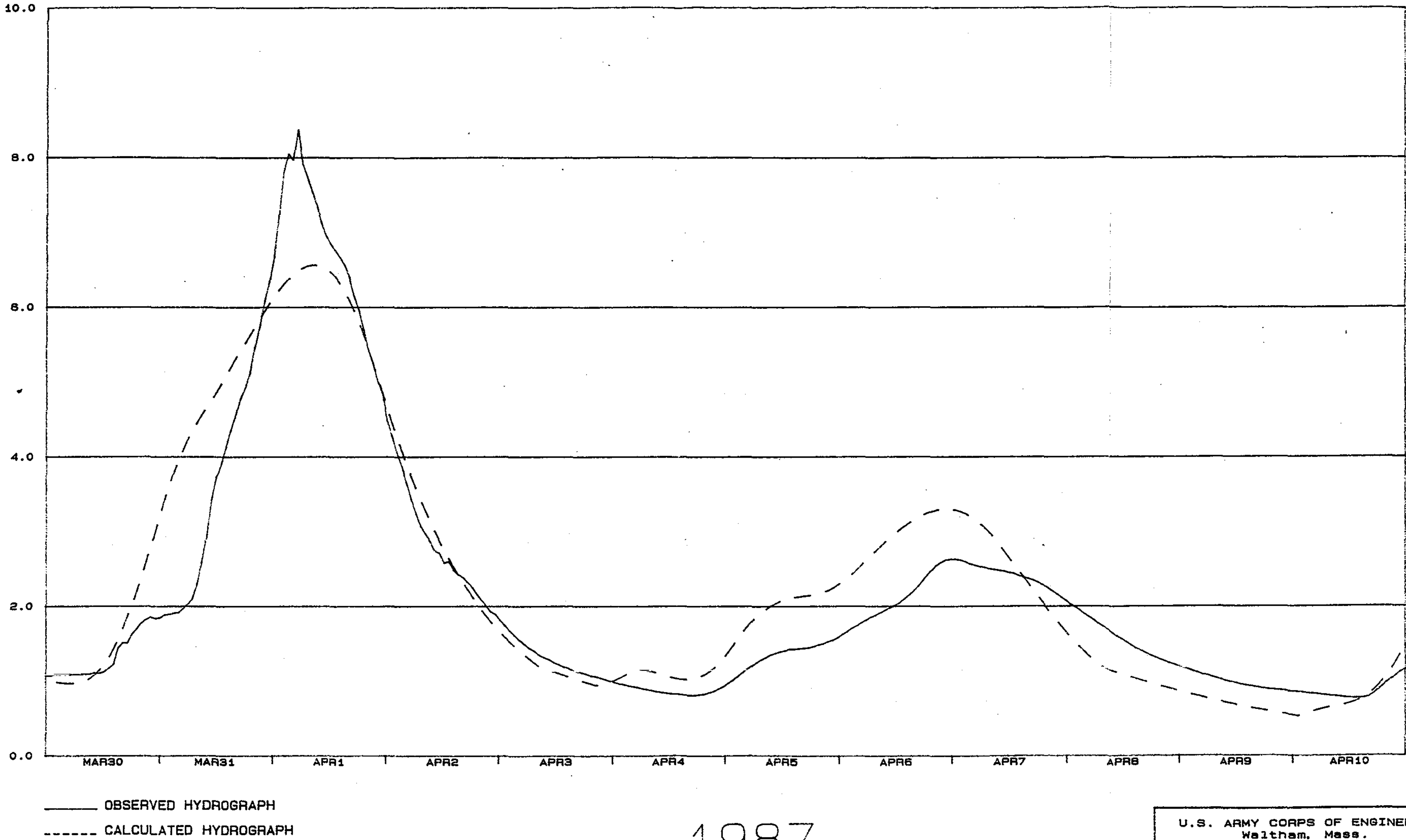
1. Reregulation of the storage available at Lake Umbagog (Errol Dam) would have had minimal impact on peak stages at Rumford, and even less impact at the more downstream damage centers. The upper lake system managed to hold back most of the rainfall/snowmelt which occurred in the upper basin.

2. The introduction of flood storage capacity at the Pontook site in Dummer, N.H., equivalent to that formulated in the 1967 Survey Report, would have had a minimal impact on flood stages as Rumford, during the 1987 flood (a reduction of 0.6 foot).

Providing similar amount of flood storage at river miles 101 or 95 (Hanover, Maine) would have resulted in significant (5 foot) peak stage reduction at Rumford, and about a 1 foot reduction at Lewiston-Auburn, the most significant downstream damage center.

4. Based on the characteristics of the 1987 flood, and using river flows only, a reasonable 12 hours of warning time could have been provided to the most upstream of the major damage centers. An additional 7 hours of warning was available to Lewiston-Auburn. The use of rainfall-intensity gages in the Wild River watershed could have added an additional 8 hours of warning at Rumford.

5. Additional information regarding the placement of rain and flow gages as part of a flood warning system may be obtained from the model by performing additional runs in which changes in rainfall intensity are introduced, and timing of threshold flooding levels are evaluated.



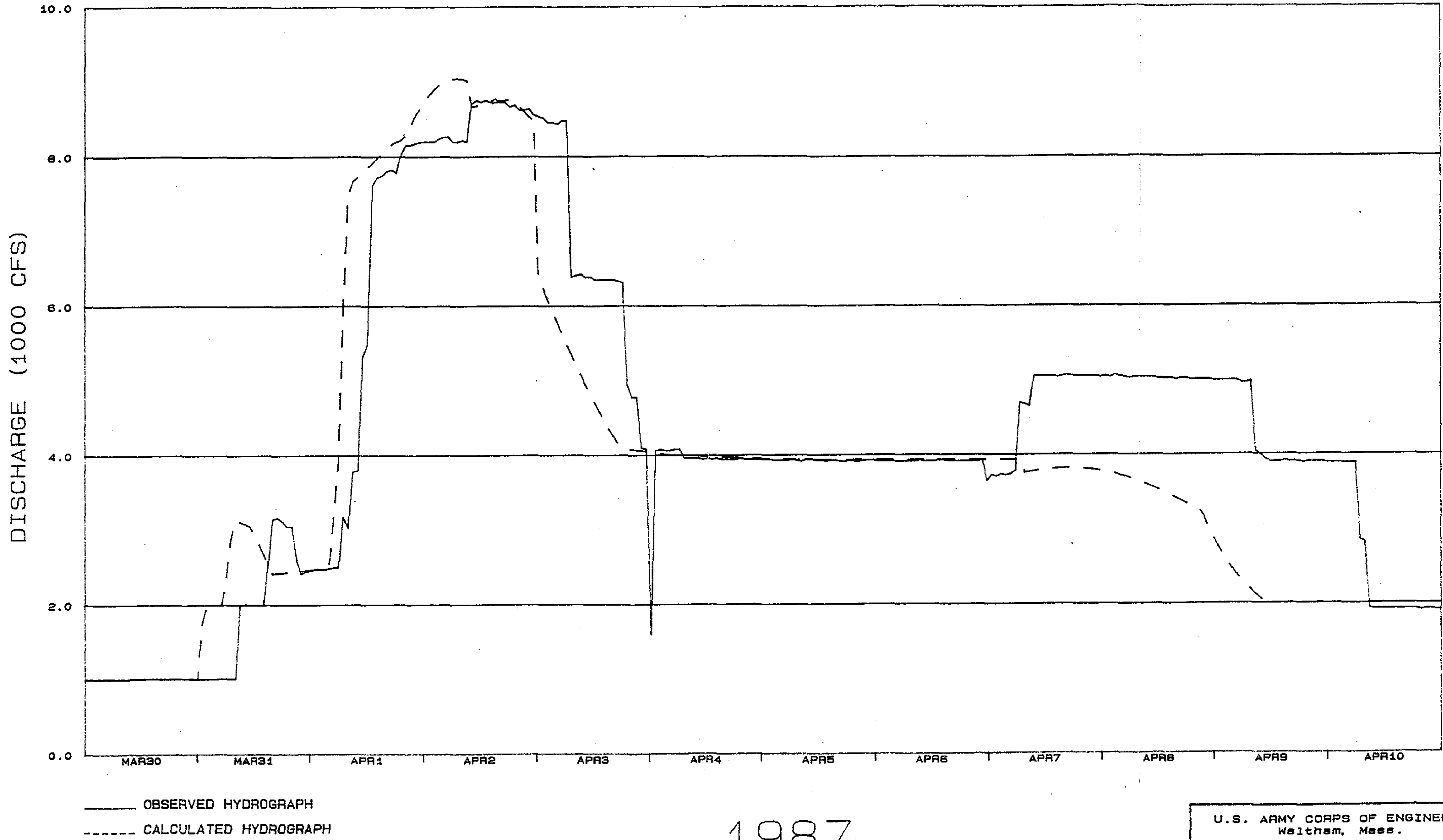

1987

NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
DIAMOND RIVER
NEAR WENTWORTH LOCATION

ROALD HAESTAD, INC. DEC 1988




1987

NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
ANDROSCOGGIN RIVER
AT ERROL, NEW HAMPSHIRE

ROALD HAESTAD, INC. DEC 1988


______ OBSERVED HYDROGRAPH

------ CALCULATED HYDROGRAPH

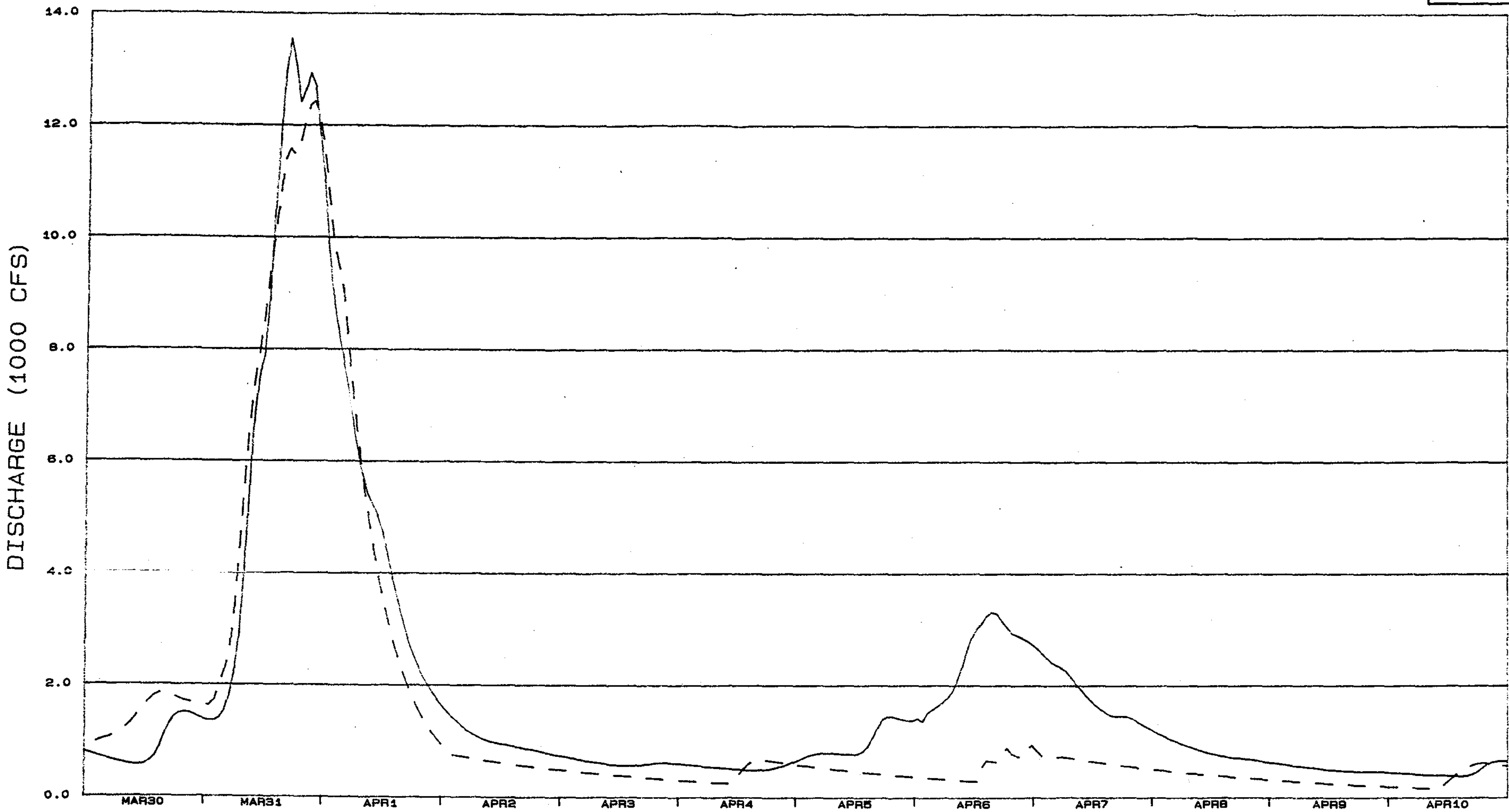
1987

NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
ANDROSCOGGIN RIVER
AT GORHAM, NEW HAMPSHIRE

ROALD HAESTAD, INC. DEC 1988




——— OBSERVED HYDROGRAPH
------ CALCULATED HYDROGRAPH

1987

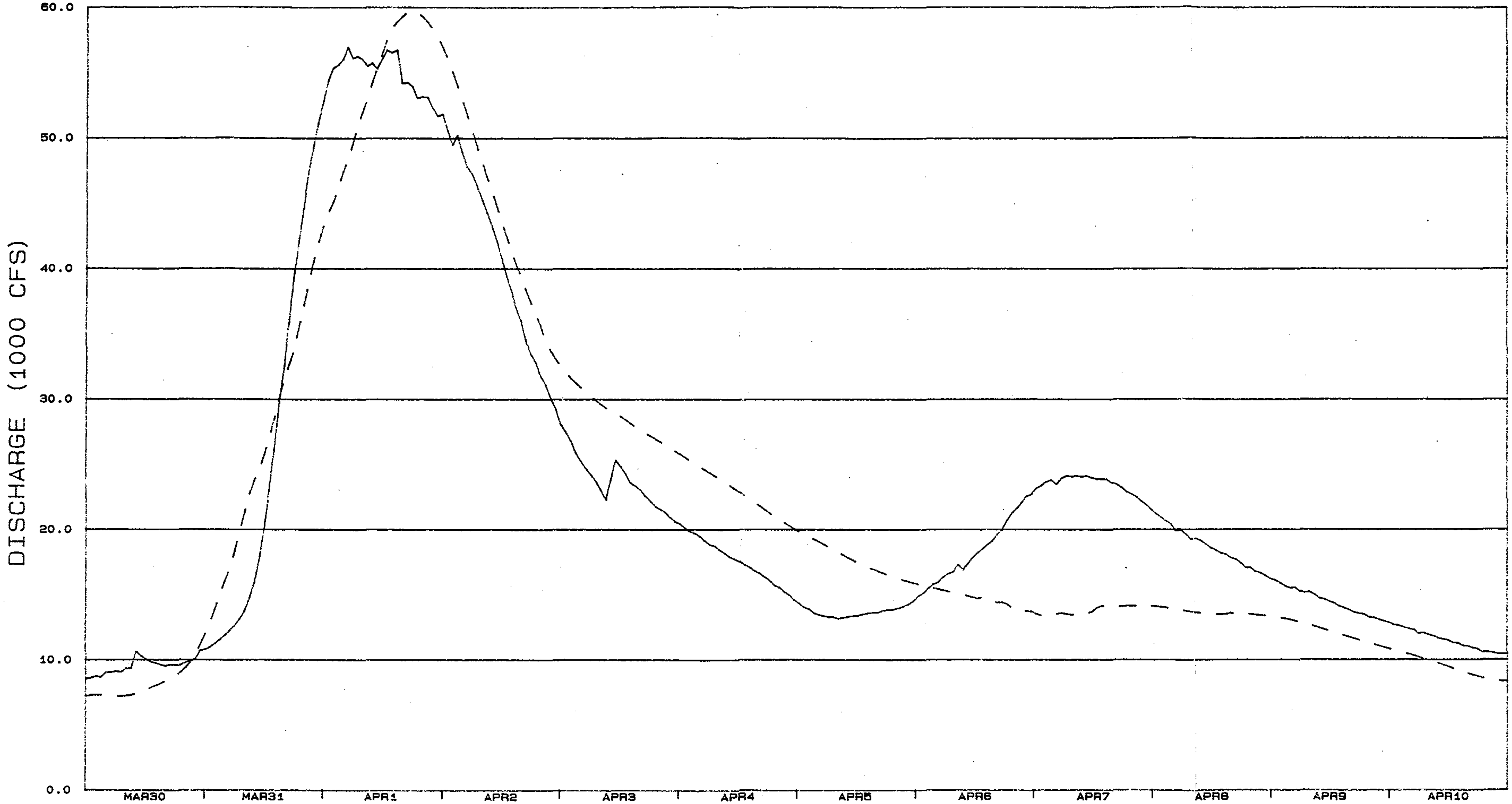
NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
WILD RIVER
AT GILEAD, MAINE

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 5 OF 11




_____ OBSERVED HYDROGRAPH

------ CALCULATED HYDROGRAPH

1987

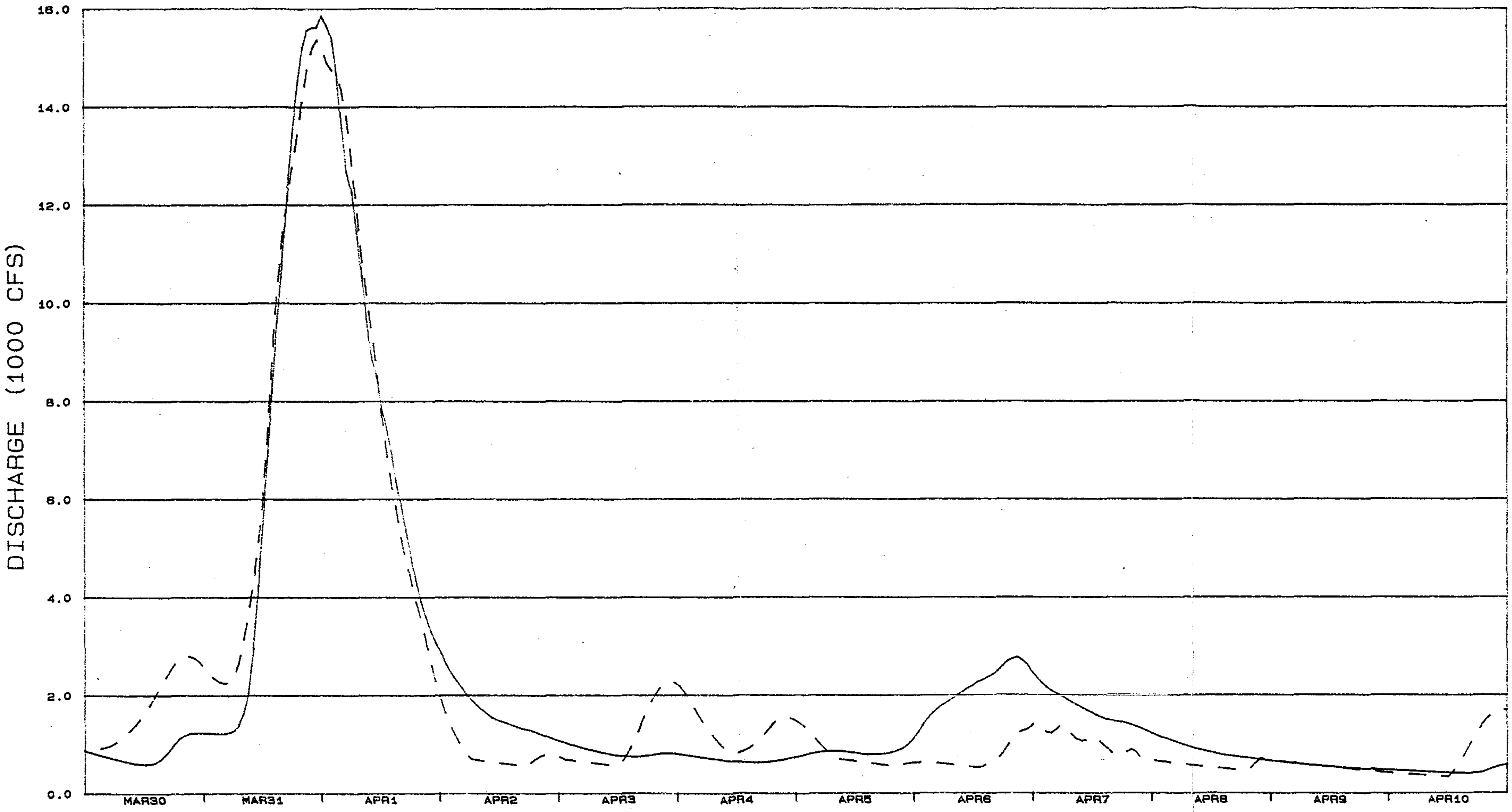
NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
ANDROSCOGGIN RIVER
AT RUMFORD, MAINE

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 6 OF 11




______ OBSERVED HYDROGRAPH

------ CALCULATED HYDROGRAPH

1987

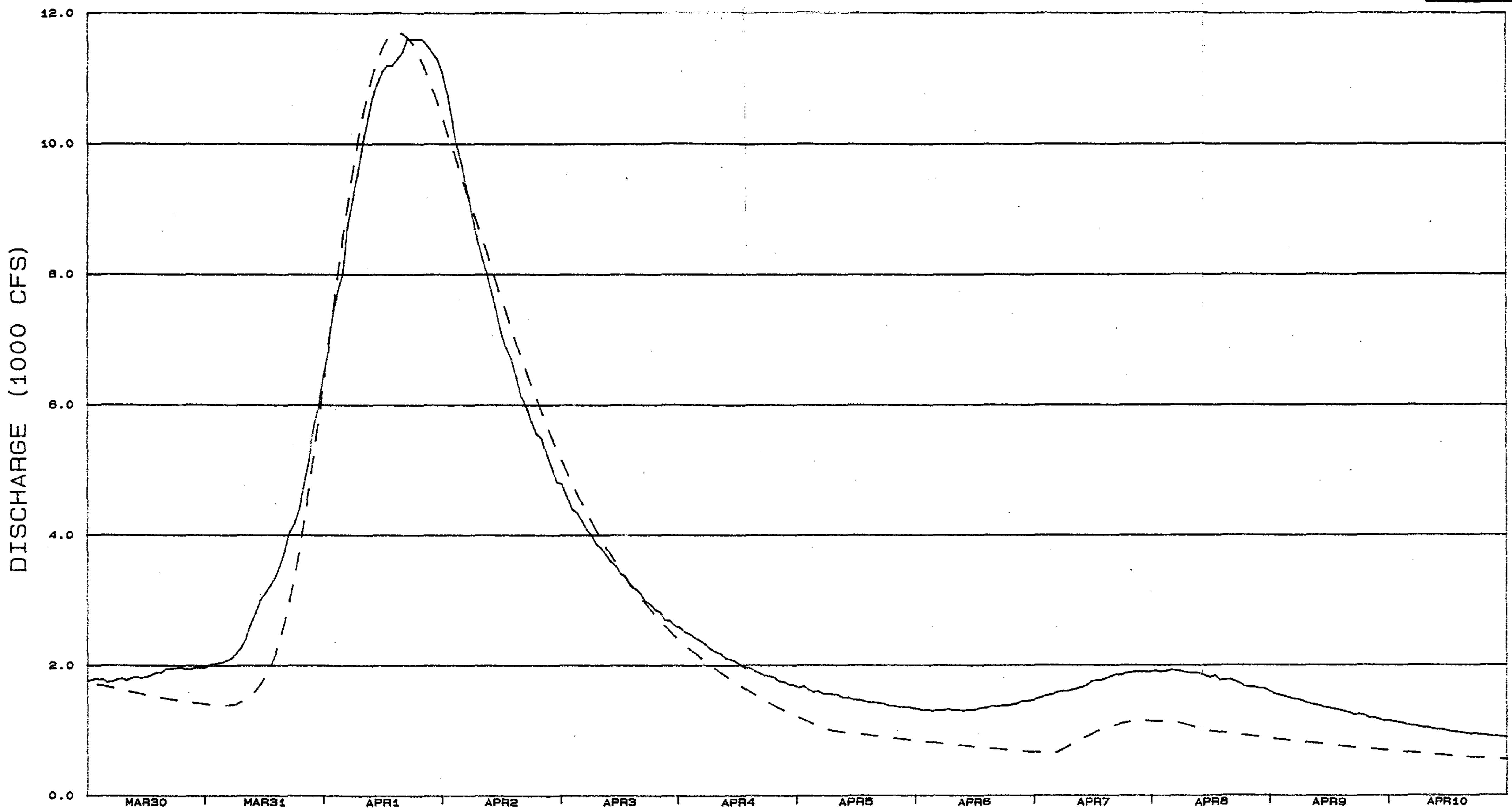
NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
SWIFT RIVER
AT ROXBURY, MAINE

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 7 OF 11




OBSERVED HYDROGRAPH
CALCULATED HYDROGRAPH

1987

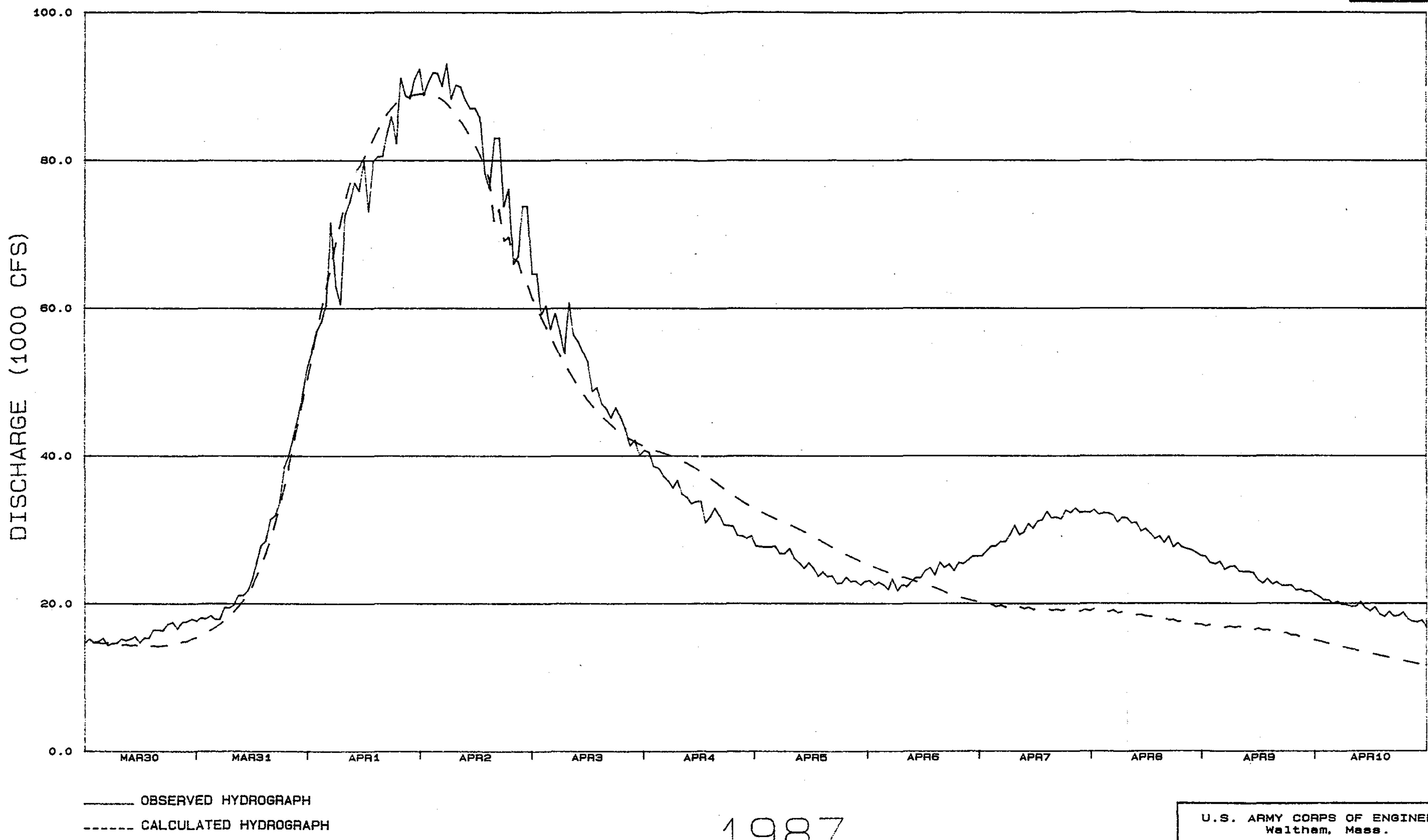
NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
MARCH/APRIL 1987 FLOOD
NEZINSCOT RIVER
AT TURNER CENTER, MAINE

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 8 OF 11




1987

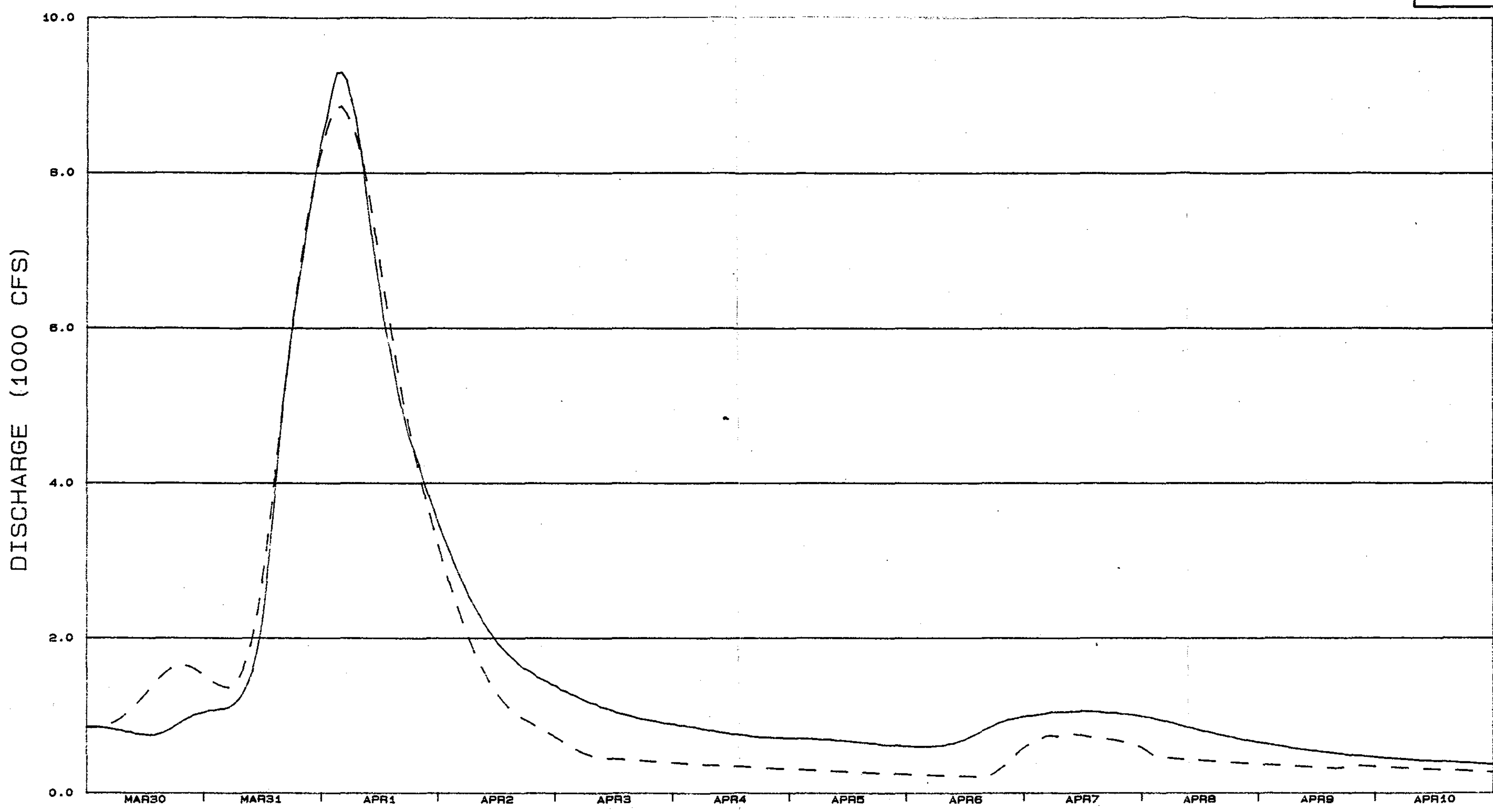
NOTE: Observed Hydrograph from Central Maine Power

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
ANDROSCOGGIN RIVER
AT GULF ISLAND DAM

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 9 OF 11




—— OBSERVED HYDROGRAPH
------ CALCULATED HYDROGRAPH

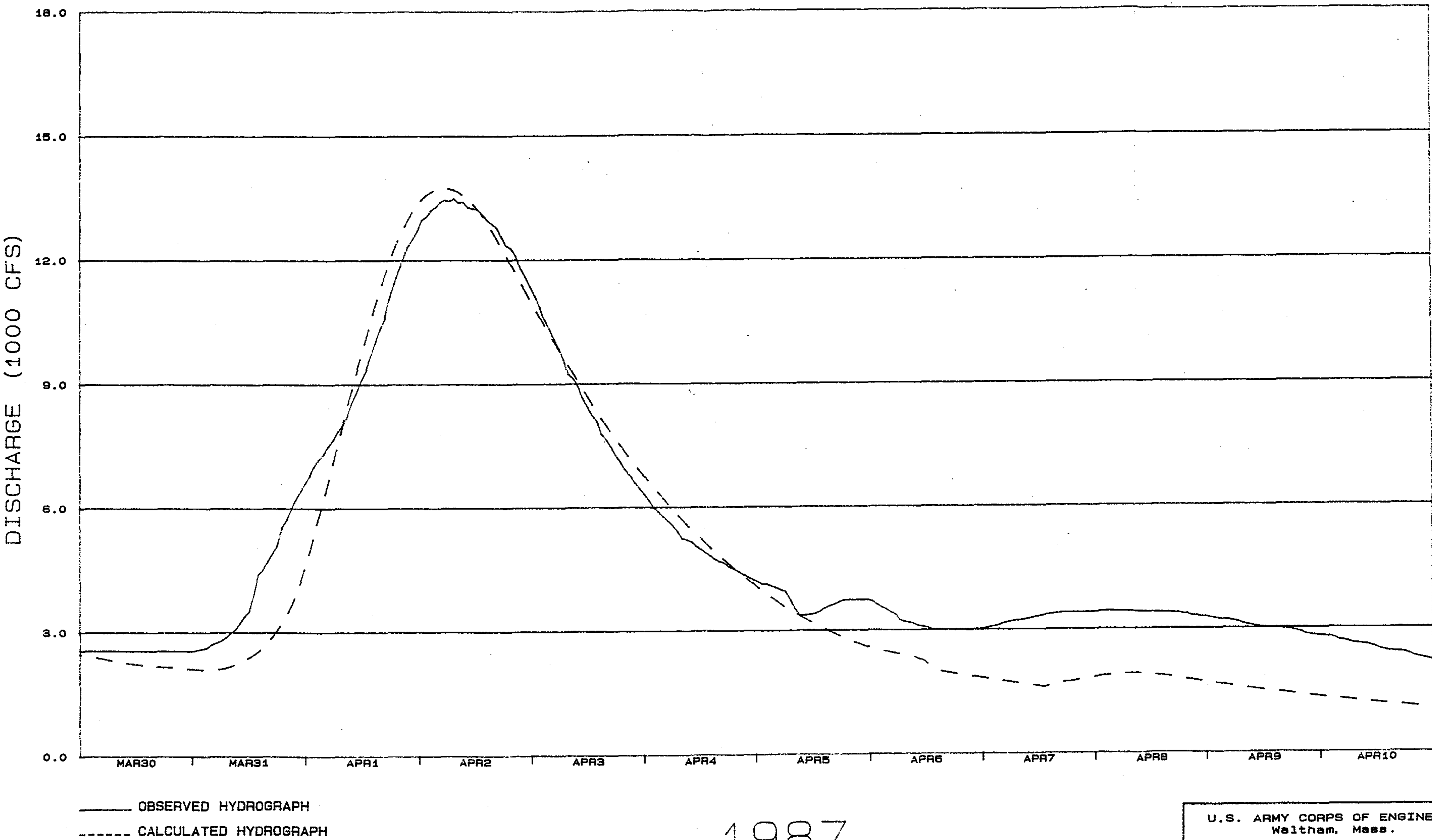
1987

NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
LITTLE ANDROSCOGGIN RIVER
AT WEST PARIS, MAINE

ROALD HAESTAD, INC. DEC 1988




1987

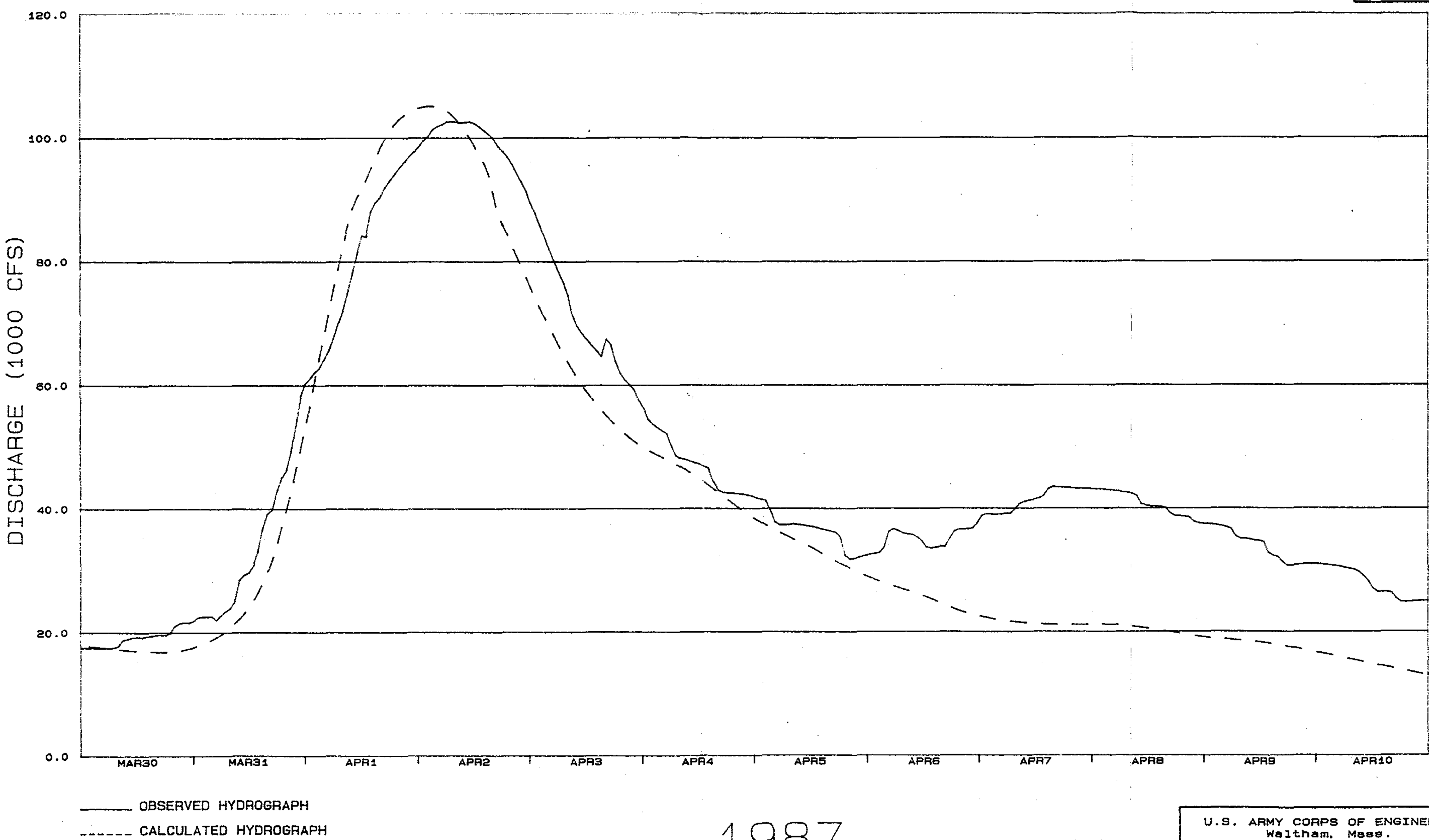
NOTE: Observed Hydrograph from Union Water Power Company

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
MARCH/APRIL 1987 FLOOD
LITTLE ANDROSCOGGIN RIVER
AT AUBURN, MAINE

ROALD HAESTAD, INC. DEC 1988

FIGURE 1
SHEET 11 OF 11




NOTE: Observed Hydrograph from USGS Gauging Records

U.S. ARMY CORPS OF ENGINEERS
Waltham, Mass.

DISCHARGE HYDROGRAPHS
FOR MARCH/APRIL 1987 FLOOD
ANDROSCOGGIN RIVER
NEAR AUBURN, MAINE

ROALD HAESTAD, INC. DEC 1988